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National Aeronautics and Space Administration

Twenty-fifth Anniversary
1958-1983

Notable views of notable people on aerospace matters...

aerospace perspectives

William H. Gregory, *Editor-in-chief, Aviation Week & Space Technology, in an editorial in that publication:*

"Congressional complaints and a draft report from the Defense Department's inspector general about pricing for spares have criticized military procurement managers for paying far more than necessary for such hardware. By implication, the report and the furor in Congress have also charged that aerospace companies are habitually gouging the government on spares pricing...

"Inaccuracies are being tossed around among all the charges. Bendix turned up in one media list with steep price increases on three different items. In the case of two of them, the early and the later prices were reversed. The price had gone down over time, not up. In the third case, as in many of the spares allegations, there was no mention of quantity. The early year price was based on a quantity of 300. The second year buy was one. The third year was 300. That single item buy left the impression of a monstrous price increase, when the first to third year comparison was not out of line...

"The inspector general's report... is confusion compounded. It is not clear what base prices are being cited. Quantities are not cited in statistics, yet quantity is a key factor in determining unit price. It is not clear whether surplus parts are being compared with newly manufactured parts. Surplus parts are obviously less costly, but great care has to be used in checking quality to ensure that they meet standards—that, for example, they are not factory rejects. One analyst said that as much as 50 percent of the actions cited as increases in the inspector general's report turned out to be price decreases on further checking...

"When some of the quirks in the defense procurement system are factored into spares pricing, the prices may still seem remarkable, but become more understandable. As an example, overhead and handling charges are billed in spares prices. On high value equipment, like an engine, such charges are a relatively small proportion. On small items like nuts and bolts, the indirect and paperwork charges—particularly in small quantities—can indeed make the price look ridiculous...

"If Congress and the Defense Dept. hierarchy want to get to the bottom of spares pricing, they ought to look at the whole spectrum of how defense procurement regulations and policies affect the way costs are structured and how handling charges and overhead are allocated. They should also look at what kind of quantities are being ordered. Further, they should consider how much paper is involved in federal procurement and how the paperwork involved is loaded onto the price of a part.

"Defense procurement regulations and procedures are so complex even experts do not fully understand them. As absurd as some buying seems to the public, there is almost always a rationale for it if no other than just following standard rules and procedures. A lot of hardworking and knowledgeable professionals in the procurement process in both industry and government are being unfairly—or outright wrongly—pilloried before the public in the spares circus now being staged by amateurs. There is plenty of room for improvement, but the horror stories being bandied about are a distorted picture."

Robert Ames, *executive vice president-aerospace, Textron, Inc. and chairman of the Board of Governors of Aerospace Industries Association, in testimony before the Subcommittee on Economic Stabilization, House Committee on Banking, Finance and Urban Affairs:*

"Clearly, the U.S. must develop positive countermeasures to offset, to the degree possible, the competitive advantages accruing to foreign manufacturers as a consequence of the support they receive from their governments. But fundamental differences between the U.S. and foreign economic, political and social systems render it unlikely that the U.S. government can, will or should provide its exporting industries with the extent of support that our foreign competitors enjoy.

"Rather, our best response lies in a traditional American strength: technological innovation. The U.S. has not lost its technological capability—only its momentum. The first critical step in regaining that momentum is fostering the recognition—within the Administration, the Congress and the American people—that American preeminence in science and technology is of paramount importance to the U.S. economy, the nation's security and its standard of living.

"That recognition must then be implemented through a *comprehensive* government policy concerning the conduct of industrial research and development. This policy should accord a higher national policy to R&D than has previously been the case; encourage more effective cooperation among government, industry and the academic community; advocate new incentives to expand industrial R&D; and acknowledge and maintain the strengths associated with competitive, decentralized decision-making by industry."

Representative Melvin Price, *Illinois, chairman of the House Armed Services Committee, in a Congressional debate over funding for antisatellite weapons, as reported by the Congressional Record:*

"An information sheet by the Center for Defense Information (stresses) that the United States should not proceed with an antisatellite system because it would destroy the opportunity to get an agreement on limiting such space systems... The Center... concedes that the Soviets have an antisatellite system and that they continue to test it. The Center's extensive discussion does not suggest that the Soviets stop testing their antisatellite system or be asked to stop deployment of their operational system.

"What is simply not clear to me is why we should not even develop any capability in this area. The Center does not explain why it is no threat to peace if the Soviets have a system deployed, as they do, but it somehow would risk a war in space if the United States even tests such a system...

"I think we should try to get away from listening to those who loosely throw out the idea that you cannot deploy any weapon that might threaten the other side's weapons in a time of crisis because they might quickly go to a use-them-

or-lose them strategy. I do not think any side is going to quickly conclude that a first strike is advantageous simply because the other side has weapons that could take out some strategic weapons or some satellite systems. It is to my mind fuzzy thinking to suggest that people are going to act in a hair-trigger way with nuclear weapons. I do not think the leaders on either side are that crazy."

Albert Wohlstetter, *president of the European-American Institute for Security Research, writing in Commentary:*

"Many of the ostensible goals of arms agreements are best achieved through measures which we can and should implement on our own. Our current efforts—which a freeze would stop—to design and deploy nuclear weapons which are more accident-proof, and more secure against theft or unauthorized use, are a good example.

"These (measures) need not mean a net increase in the numbers or destructiveness of nuclear weapons in our stockpile . . . If we increase precision further, we can drastically reduce the number and destructiveness of our nuclear weapons. Increased precision can also improve the effectiveness of conventional weapons so that they may increasingly replace nuclear brute force. And it would improve our ability to avoid the unintended bombing of innocents with nuclear or conventional warheads. It would enlarge rather than foreclose our freedom to choose."

Carlton E. Spitzer, *senior vice president, Manning, Selvage & Lee, Washington, D.C., writing in Public Affairs Review:*

"The politican claims he cannot take the long view because he must respond to the immediate cries of his constituents and those who support his campaigns. The business executive says he cannot take the long view because he is judged on the next quarterly earnings statement. The banker and investor too often agree with him. The labor leader cares about America's future as much as the next man but today's jobs are the issue and he argues for propping up dying industries and keeping foreign-made products out of our stores. The appointed government bureaucrat says his actions must support the administration that put him behind his desk. Everyone must deal with the here and now. Who, then, builds for the future?"

McAllister Retires

Regular *Aerospace* readers may note the absence of a familiar name in the adjacent masthead, that of Gerald J. McAllister, editor of *Aerospace* since its inception in 1963. After more than 27 years service with Aerospace Industries Association, McAllister has retired. His editorial talent, experience, good humor and extensive knowledge of the aerospace industry will be sorely missed.

AIA

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CONTENTS

2 NASA: 25 YEARS . . . AND THE NEXT 25
By James J. Haggerty

10 U.S. SPACE POLICY: THE NEED FOR NEW DIRECTIONS
By Senator Larry Pressler

12 MAKING HISTORY AT PAX RIVER
By Laura Overstreet

15 NATIONAL BENEFITS OF AEROSPACE EXPORTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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NASA:

25 Years...and the Next 25

BY JAMES J. HAGGERTY

Chances are you don't remember Pioneer 1, even if you're old enough to have witnessed the beginnings of U.S. space flight. It was no big deal, a 1958 lunar probe that failed to go the distance but was hailed as a milestone because it reached an altitude of 70,000-plus miles. It has a more legitimate claim to milestone status in that it was NASA's first spacecraft.

Pioneer 1 was launched on October 11, 1958, just 10 days after NASA officially opened its doors for business. So, on October 1 or October 11, depending on your viewpoint, NASA will mark its 25th anniversary of space operations. The aeronautical research component of NASA's work, acquired in 1958 from the old National Advisory Committee for Aeronautics (NACA), dates back to 1915, when NACA was created.

In its 25 years of existence, NASA has compiled an extraordinary record of exciting accomplishment, technological excellence and managerial competence. Its efforts have contributed immeasurably to restoring and maintaining the once-tarnished U.S. image as world leader in science and technology and, at the same time, they have generated a wealth of benefit to the nation, even if the benefits are sometimes only dimly perceived.

NASA's space science program, which has produced more knowledge of the solar system and the universe than man had acquired in all the prior years of history, represents a practical as well as a scientific benefit, because the immense volume of information gathered provides a broad foundation for future technology development.

The agency's pioneering work on space applications—direct benefit systems—paved the way for the communications and environmental satellites now in operational service. It promises future benefits of even greater potential, such as Earth resources monitoring for more effective management of the planet's resources and orbital manufacturing of products not producible on Earth.

NASA aeronautical research has generated a succession of technology advancements of great benefit to the U.S. in terms of the national economy, stronger defense, improved competitiveness of American aircraft manufacturers, reduced environmental impact of the airplane and greater safety for all who fly.

And the "spinoff" or secondary use of technology developed in all these programs has produced literally thousands of new products and processes, which in turn created new jobs, in some cases whole new industries.

For all its dramatic accomplishments, NASA's first quarter century has been largely a period of development, a time of building advanced capability not only to explore space but to exploit it. The Space Shuttle is a big step in that direction; providing routine access to orbit, it offers an opportunity to pursue some of the direct benefits space promises. But real exploitation of space will require considerably more capability development—the space station, for example, and a variety of new systems associated with it.

So NASA's second quarter century will see the civil space program proceeding simultaneously on two fronts. On the one hand, NASA will be developing advanced technology for a permanent, substantially broadened manned presence in space. On the other, we will see the beginning of a major new thrust in exploiting space for direct Earth benefit, initially in such areas as orbital manufacturing, monitoring Earth's land and sea resources on a global scale, advanced space communications and long range environmental prediction.

How these advances will be pursued is outlined in the latest NASA Program Plan, which details what agency thinkers have in mind for coming years. Many of the programs it describes are already approved and launched; others represent a kind of "wish list," projects that are logical and profitable extensions of current effort, feasible in a certain time frame; they are good possibilities for tomorrow but are not yet approved or funded for hardware development. Collectively, the ongoing and hopefully-comtemplated programs paint an exciting picture of the civil space future; they are summarized in the following pages.

What's Next in NASA Aeronautics

A unique new airplane will take to the skies next spring, probably startling some observers; they may think its wing was installed backward. The plane is the Grumman-built X-29A, featuring wings swept forward instead of aft; this design technique, coupled with use of composite materials, offers potential for building aircraft lighter, smaller and less costly than equivalent performance planes with aft-swept all-metal wings.

The X-29A is one example of NASA's High Performance Aircraft Program, conducted in cooperation with the Department of Defense and industry. The program is directed toward advancing technologies that will find first use in military aircraft but which also promise future benefits in civil aircraft applications. Among other projects are the General Dynamics AFTI F-16 and AFTI F-111, both part of the joint USAF/NASA Advanced Fighter Technology Integration program. Already in flight status, the AFTI F-16 features all-electronic flight controls instead of the conventional assembly of rods and linkages. Scheduled for first flight next summer, the AFTI F-111 will have a Boeing-fabricated wing whose camber is automatically changed as flight conditions change, optimizing cruise performance and maneuverability.

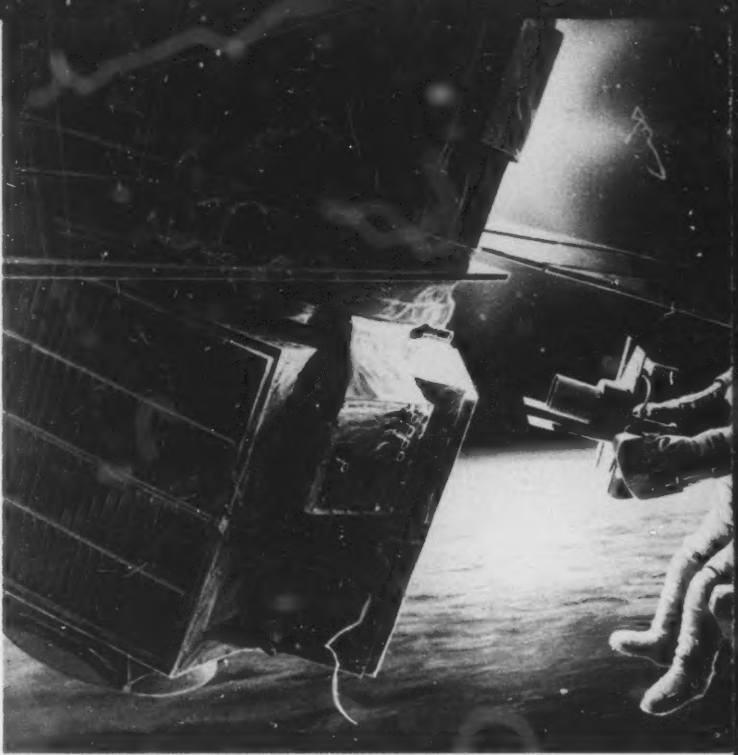
A fourth project is a NASA/General Dynamics investigation of the "arrow wing" technology, originally developed by NASA for supersonic civil transports, in a modified fighter known as the F-16XL; two XLs are undergoing flight test. NASA's High Performance Aircraft Program also includes design and model testing of advanced fighter/attack concepts and laboratory tests of advanced propulsion systems.

In civil aircraft research, a project of special NASA focus is the Advanced Turboprop, which offers jetlike commercial transport speeds with fuel consumption 15 to 20 percent lower than turbofan engines. NASA recently launched development of an advanced turboprop test assembly—propeller, engine, gearbox—to begin flight evaluation in 1987. NASA is also conducting an Energy Efficient Transport Program that combines engine fuel efficiency with use of electronic flight controls for a sharp reduction in fuel consumption. The agency's work on composite materials, usually lighter yet stronger than the metals they replace, has resulted in use of composites as secondary structures on new jetliners; the next step, now under way, is to develop technology for application of composites in *primary* structures of large civil and military transports, a step that can provide really dramatic weight, fuel and cost savings.

In rotorcraft research, NASA will continue to fly the Bell Helicopter Textron XV-15 Tilt Rotor Research Aircraft, expanding the operational envelope to provide data useful to the Department of Defense in its JVX tilt-rotor development. NASA will also continue its advanced helicopter investigations with the Sikorsky-built Rotor Systems Research Aircraft (RSRA), a flying laboratory for testing various rotors applicable to future helicopters or compound helicopters. A major new start in FY 1984 will be a joint program with the Defense Advanced Research Projects Agency (DARPA) to investigate further the "X-wing" concept, in which a wide-bladed rotor system used for vertical lift converts to a fixed wing for forward flight. DARPA conducted several years of wind tunnel experimentation; the new program will involve design and fabrication of a full-scale X-rotor, its integration with the RSRA, and flight tests.

Among long range programs, NASA plans further investigations of the oblique wing, which can be pivoted in flight to various angles for greater aerodynamic efficiency at supersonic speeds while maintaining good efficiency at lower speeds. This year NASA completed a 38-flight program of the AD-1 research airplane, demonstrating the wing's low-speed efficiency. Next, NASA plans to incorporate the wing in a modified military aircraft for flight testing at speeds at least up to Mach 1.2. In a separate program, NASA contemplates flight tests of lightweight, high-performance wings for supersonic cruise flight that offer efficiency improvements of 30 to 50 percent at Mach 2 and beyond. NASA will also develop a technology base for a supersonic STOVL (Short TakeOff and Vertical Landing) aircraft capable of operating from a variety of bases, including small ships and damaged runways.

What's Next in NASA Space Operations



Next year NASA will attempt to "capture" and repair in orbit the malfunctioning Solar Maximum Mission spacecraft. The artist's concept shows an astronaut equipped with a Manned Maneuvering Unit docking with Solar Max.

Coming up in the spring of 1984 is an important "next step" in the U.S. development of space capability: the first demonstration of the Space Shuttle's ability to retrieve orbiting satellites for servicing on the spot or return to Earth for refurbishment, thus allowing a lengthy extension of a satellite's working lifetime. The initial retrievee is the Sun-studying Solar Maximum Mission spacecraft, which has been producing only limited data since the 1981 failure of its attitude control system.

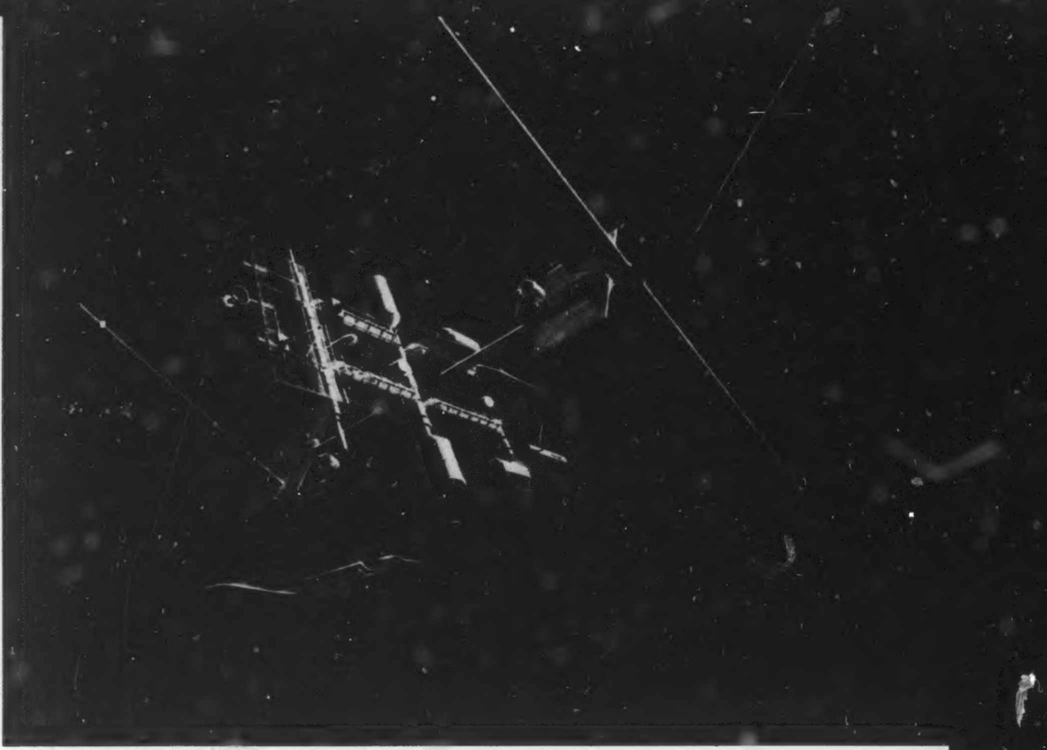
Launched in 1980, Solar Max was the first satellite designed for retrievability; it has a fitting that the Shuttle Orbiter's robot manipulator arm can grapple to haul the spacecraft into the Orbiter's cargo bay for replacement of the attitude control module. The task sounds simple enough, but it's really a very challenging and somewhat risky mission. Solar Max is not stable; it is sort of slow-rolling its way in orbit. Remember, although space operations sometimes appear to be conducted in slow motion, both the Shuttle and the satellite are moving at 17,500 miles per hour; even a slight bump from the corkscrewing Solar Max could be disastrous to the Shuttle crew. So the Orbiter must maintain a safe distance while someone goes out—literally—to stabilize Solar Max.

The someone is Mission Specialist Dr. George D. Nelson, who will be flying the Martin Marietta-built Manned Maneuvering Unit (MMU), a one-man backpack spacecraft that provides space suit pressurization, flight controls and thrusters for maneuvering. Nelson will fly solo to Solar Max, grasp its retrieval fitting, then fire his MMU thrusters to correct the satellite's rolling motion. With Solar Max stabilized, the Orbiter can move in close enough for the robot arm to capture the satellite. After repair, Solar Max will be redeployed in orbit to continue its study of solar phenomena.

Although manned extravehicular activity will figure in future retrieval servicing operations, much of this work will be taken over by a new vehicle known as the Teleoperator Maneuvering System (TMS). The TMS is a robot with manipulating arms and its own propulsion system; its maneuvers and manipulations are human-controlled from the Shuttle Orbiter, an Earth station or a space station. It will be used to deposit payloads in orbit, to inspect and photograph satellites already in orbit, to grapple and return them to the Orbiter or space station, or to serve as a free-flying subsatellite operating near an Orbiter or a space station. Planned for a developmental start in Fiscal Year 1985, the TMS could be operational by 1988.

NASA plans a number of improvements to the Shuttle itself, including provisions for additional life support and power supplies to extend the Orbiter's time in space to two weeks by the latter 1980s. Another improvement contemplated for the 1980s is the Aft Cargo Carrier, a container that would fit below the Shuttle's external fuel tank and allow a big increase in the volume of cargo the Shuttle can deliver to orbit. Looking farther down the road, NASA is studying a Shuttle-Derived Cargo Vehicle to carry large, heavy payloads from the ground to low Earth orbit in the era of the space station. Targeted for service about 1994, it would be an unmanned vehicle based on the Shuttle's boost system, with a huge payload canister substituted for the Orbiter.

One of the most important systems on the development agenda is the Orbital Transfer Vehicle (OTV), a high energy upper stage that would be reusable. Permanently based at a space station, OTVs would be used initially to boost heavy payloads from low Earth orbit (LEO) to geosynchronous Earth orbit (GEO), the 22,300-mile altitude where most commercial satellites operate. Later, an OTV fitted with a Teleoperator Maneuvering System would allow retrieval and servicing of satellites in GEO, which is far beyond the Shuttle's altitude capability. However, a real capability for GEO servicing and repair will demand human presence; toward that end, NASA is thinking of an advanced OTV that would include a crew capsule along with a tele-



The next giant step: a multimodule, human-habitable space station, the initial version of which could be in service by 1991. This is one concept —by TRW Inc.—that emerged from a recent round of industry studies.

operator system.

For the foreseeable future, the Shuttle Orbiter's time in space will be limited to about two weeks. But some science and applications payloads require much longer duration, years in some cases. Rather than fly many such payloads individually, NASA is planning a system whereby a number of long duration payloads would be aggregated in a large unmanned space platform. The platform will supply electrical power, communications, attitude control and thermal control for all of its multiple payload pallets. One Shuttle-serviced platform would, in effect, replace several individual satellites, providing large scale economies. The first platform, operating in LEO, is targeted for the latter 1980s; the plan contemplates later development of multipayload platforms in GEO.

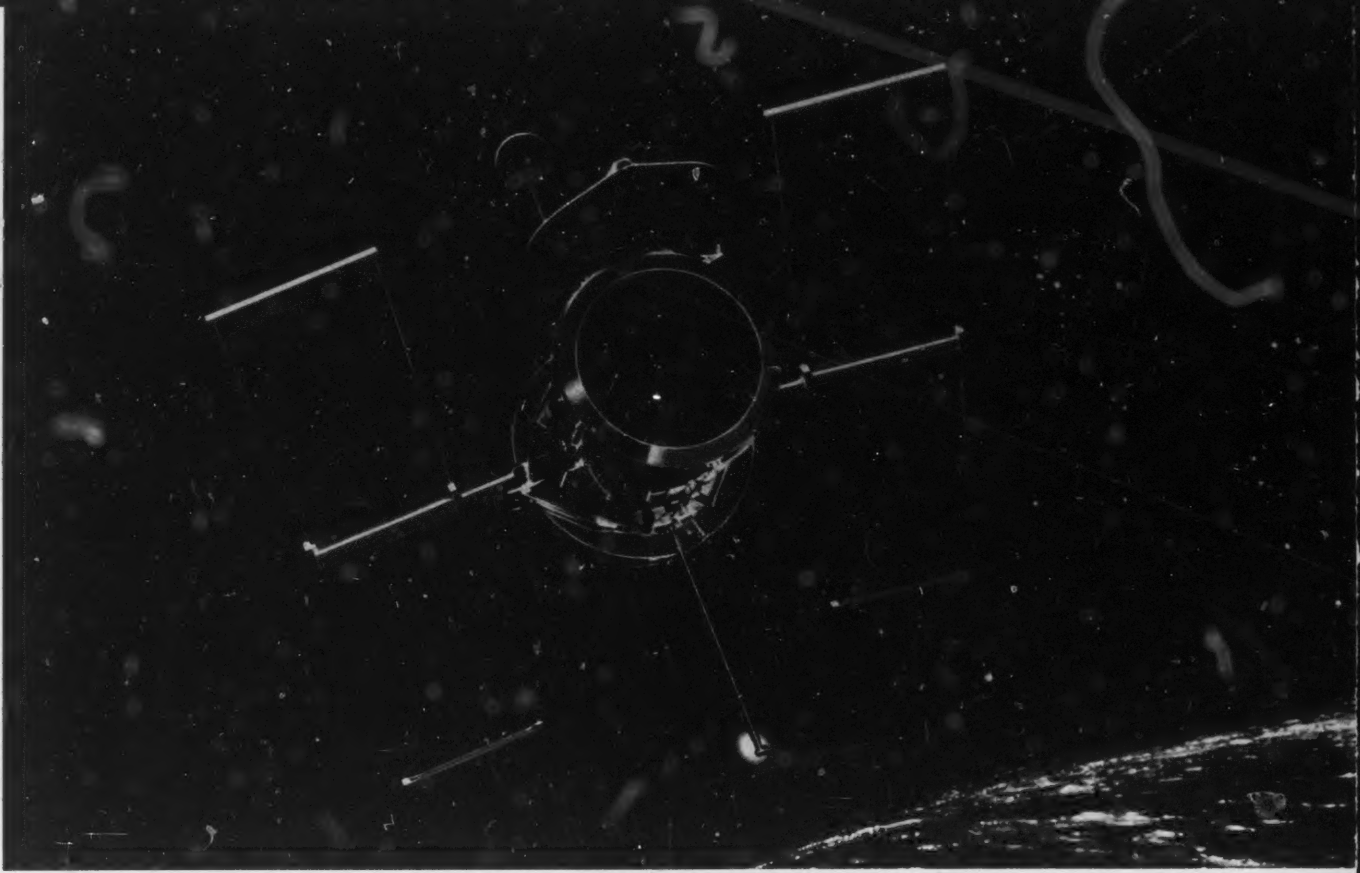
A major advance planned is development of Shuttle capability for erecting in orbit structures too large to be boosted from Earth—very large antennas, for example, or factories for manufacturing in space, or facilities for periodic human presence in GEO. A first step, to be tested about 1987-88, is the Deployable Antenna, Shuttle-delivered as a compact package that unfolds in orbit to a dish half the size of a football field. In the mid-1980s, NASA will begin experiments in erecting even larger structures by assembling segments produced by a Shuttle-based automated beam builder.

The key element in advanced space operations is, of course, the permanent manned station in low Earth orbit. NASA is now developing "architectural options," blueprints for a modular-design station that could be expanded over time by addition of habitable modules, supply modules and other equipment. If the Administration and the Congress signal a go-ahead by the time the program definition phase is completed in 1985, the initial station could be in service by 1991. It would allow continuous, rather than intermittent, space operations; it would provide a platform for human-directed scientific experiments and direct benefit systems; it would be a departure point for boosting payloads to GEO or for missions to the planets, asteroids and comets; it would serve as a base for assembly, deployment and servicing large spacecraft and multifunction platforms; it would house facilities for space manufacturing; and it would be the supply and operations center for space construction work.

Since all these plans are dependent upon annual appropriations, the timetable is necessarily imprecise, but NASA's Program Plan suggests these targets:

- **The 1980s:** improving Shuttle capability, conducting the initial series of Spacelab missions, increasing Shuttle launch frequency, servicing satellites in LEO.
- **1985-90:** introduction of the Teleoperator Maneuvering System, development of the Orbital Transfer Vehicle, first demonstrations of deploying large structures, initial operation of multifunction platforms in LEO.
- **1991-1995:** Operation of the initial space station, introduction of the OTV, payload servicing in both LEO and GEO, erection of large structures in orbit.
- **1996 to 2000 and beyond:** Deployment of multifunction platforms in GEO, development of a manned OTV for shuttle between LEO and GEO and, in the latter part of NASA's second quarter century, first operational use of a periodically-manned facility in GEO.

Accomplishment of these steps would allow continuous, efficient, routine operations in both low and high Earth orbit and set the stage for such currently considered but still remote possibilities as manned missions to the planets, unmanned probes beyond the solar system, or mining the moon and the asteroids for mineral resources to be processed at a lunar base or Earth-orbiting space colony.



Operating above the distorting influence of Earth's atmosphere, the Space Telescope will be able to "see" seven times farther into the universe than the best ground-based telescopes. It is slated for launch in 1986.

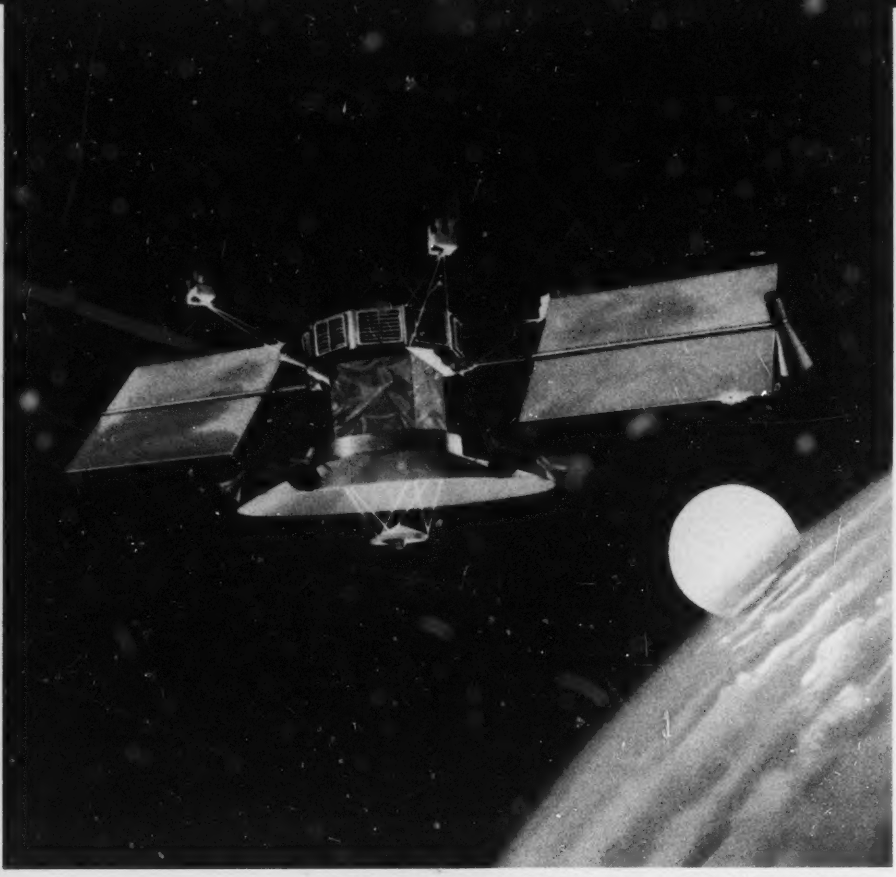
What's Next in NASA Space Science

In September 1985, a comet called Giacobini-Zinner will approach Earth on its path past the Sun. NASA's ISEE-3 spacecraft will be there to meet it, fly directly into its tail and send data to Earth on temperatures, gases, particles and magnetic forces. This will be the first close-up investigation of a comet, a particularly important area of space science research because comets are apparently little changed by time, thus offer clues to cosmic material as it existed in the solar system's earliest days.

A few months later, Comet Halley will make its once-every-76 years close encounter with the Sun. The European Space Agency (ESA), Japan and the Soviet Union will send spacecraft to "interview" Halley. Budgetary considerations precluded NASA's development of a Halley mission, but the U.S. will nonetheless be very active in Halley observations. ISEE-3 may be able to provide some data, and NASA is also participating in the ESA mission, named Giotto. Additionally, the U.S. and Germany will sponsor an International Halley Watch that will involve collection and analysis of data acquired by all nations' spacecraft, aircraft, balloons and Earth-based facilities.

Comet study is one part of NASA's program of interplanetary exploration, now known by the broader tag "exploration of the near universe." The aims of the program are to determine the origin and evolution of the solar system, to learn more about Earth through comparisons with other bodies in the solar system, and to investigate resources on the planets, moons and asteroids toward their possible future utilization. In addition to the comet investigations, these projects are already in being or in development:

- Pioneer 10 and 11, having almost concluded a grand tour of the outer planets, are at the edge of the solar system, still reporting data and about to move into interstellar space. Pioneer 10 is already beyond the outermost planet, but technically it will not depart the solar system until 1986. In fact, no one knows just where the solar system ends and the two Pioneers are providing data toward determining the boundary.
- Voyager 2 is en route to a 1986 flyby of Uranus and a 1989 encounter with Neptune; neither planet has been visited by spacecraft. The companion Voyager 1 will help the Pioneers define the solar system boundary.
- The Galileo spacecraft, comprised of a Jupiter-orbiting observatory and a probe to descend into Jupiter's atmosphere, will be launched in 1986.



Intended for service in 1988, the Venus Radar Mapper will map the never-seen surface of cloud-shrouded Venus with far greater clarity of detail than was possible with the earlier Pioneer Venus.

- A joint ESA/NASA International Solar Polar Mission is to be launched in 1986; the ESA-built spacecraft will explore a virgin area of space by flying around the Sun's poles, rather than in the solar equatorial plane where all prior spacecraft operated.
- The Venus Radar Mapper, to be Shuttle-launched in 1988, will map Venus' surface with a clarity of detail significantly better than the maps provided by the earlier Pioneer Venus.

In addition to these programs, NASA contemplates developmental starts, within this decade, of a Mars Geochemical/Climatology Orbiter to expand knowledge of the Red Planet; a rendezvous and long-duration closeup study of a comet; and a mission to map and probe the atmosphere of Saturn's largest moon Titan, which offers what may be the only atmosphere in the solar system similar to Earth's before life started on this planet.

For the years beyond 1990, NASA is thinking of advanced long-duration orbiter/probe missions to Mars and Venus; the first closeup look at an asteroid; a sample return from a comet; and orbiter/probe flights to Saturn and Uranus. Beyond 2000, NASA accords high priority for flyby/probe missions to Neptune and Pluto.

In 25 years of spacecraft operation, scientists have accumulated an immense volume of data about Earth, but it only underlines how little we know of the complex forces that govern our planet. There is need for a thorough understanding of these forces, not only for scientific gain but for an underlying practical reason—protecting the future habitability of the planet. NASA has embarked upon a comprehensive multi-mission study of the processes that link Earth and the Sun—how energy is transported to Earth, how the energy transfer influences Earth environment, and, in particular, how human activities may effect the physical processes that take place in a near-Earth zone known as geospace.

Several spacecraft are already providing data in this area. Among new programs in development or planned are the Earth Radiation Budget Explorer, to be launched next year for a study of the factors that determine Earth's climate; the Upper Atmosphere Research Satellite, planned for launch late in this decade, which will make global observations of the chemical composition and energy transfer mechanisms in the upper atmosphere; and the Origins of Plasma in the Earth Neighborhood (OPEN) program, in which four heavily instrumented laboratories, operating as a team, will conduct the first quantitative study of the complete geospace system and the interactive behavior of its various components.

Another area of space science is study of the distant cosmos toward knowledge of how the universe is structured, how it is changing, how it began and whether it will have an end. The key program in this study is the Space Telescope; planned for 1986 launch, it will look seven times farther into space than the best Earth telescopes and detect objects 50 times fainter. The Space Telescope may permit astronomers to see to the very edge of the observable universe and it will literally allow scientists to look back in time billions of years, because the light they will be viewing was generated long before our solar system was created.

Visible light, however, represents only a small portion of the radiation emanating from space, much of which is absorbed or filtered by Earth's atmosphere, hence is largely invisible to ground observatories. To complement the findings of the Space Telescope, NASA is developing a series of imaging spacecraft that will make observations in the non-visible infrared, x-ray, ultraviolet and gamma ray regions of the spectrum. The first, already in orbit, is the Infrared Astronomical Satellite (IRAS), which recently made headlines by discovering what may be another solar system around the star Vega. A more sensitive follow-on to IRAS, to operate from the Shuttle Orbiter starting late in this decade, is the Shuttle Infrared Telescope Facility.

Among other new astronomy projects planned or in development for launch over the next 10 years are ROSAT, a U.S./Germany x-ray investigator; the Gamma Ray Observatory, which will study how gamma rays are generated and where they come from; the Cosmic Background Explorer, the first spacecraft designed specifically to seek data on the beginnings of the universe; and the Advanced X-ray Astrophysics Facility, which will have instruments with about 100 times the sensitivity of those in prior x-ray spacecraft. Collectively, these and other astronomical systems will enable study of infant stars and dying stars, cosmic dust clouds where new stars may be forming, and the little-understood processes involved in the creation of galaxies, quasars and black holes.

What's Next in NASA Space Applications

In 1963, NASA pioneered the use of the geosynchronous orbit that allows a satellite line-of-sight communications with Earth for 24 hours daily, where earlier satellites could send signals only when they were "in view" of a ground station. The NASA technology provided a foundation for the commercial communications satellite networks that followed, so far the broadest area of direct benefit to emerge from applications of space technology to Earth needs.

Since 1963, about 150 communications and other satellites have been launched into geosynchronous orbit—and therein lies an incipient problem. Since all geosynchronous satellites operate at the same altitude—22,300 miles—the GEO orbit is becoming crowded and proximity can cause one satellite's signals to interfere with another's. The problem is not yet acute, but it bids to become so with an estimated 350 GEO satellites slated for service by the end of the century.

To forestall a possible communications logjam, NASA is developing technology that would greatly expand the capabilities of communications satellites. One method of increasing space-relayed message capacity involves satellite generation of multiple "spot" beams, each focused on a narrow Earth region, rather than the wide beams now generated. The spot beams would "hop" in sequence from one ground station to another, transmitting in a rapid burst all the signals stored since the last time the beam covered that station. This hopping would occur thousands of times a second, so satellite communications users would be unaware of the interruptions.

The spot beam approach is analogous to adding new lanes to an existing highway for greater capacity. Another approach compares with building an entirely new parallel highway: opening a new frequency range in addition to the two now used. Known as the Ka-band, this frequency range offers five times the capacity of either existing band, but it is not currently used because it is highly susceptible to weather-caused interference. NASA's task is to develop means of preventing loss of signal quality in transmissions through thunderstorms. A new program called the Advanced Communications Technology Satellite will combine the spot beam and Ka-band approaches in a demonstration system planned for orbital tests in 1988.

Installed on the mid-deck of the Space Shuttle Orbiter, McDonnell Douglas Corporation's EOS experiment is pioneering space production of advanced pharmaceuticals. Processing materials in the gravity-free space environment holds promise for manufacture of a broad range of superior Earth products.

NASA's work in communications technology represents one facet of what the agency calls its "applications" program, intended to produce direct public benefit by exploiting space technology. Other products of this program include the operational environmental and land resources survey (Landsat) systems operated by the National Oceanic and Atmospheric Administration, and the new SARSAT search and rescue system that monitors signals from downed aircraft or ships in distress.

Next year, NASA will orbit a new Landsat 5 to replace the malfunctioning Landsat 4; the agency may later opt to retrieve and repair Landsat 4. NASA continues to develop advanced instrumentation for land resources survey, but remote sensing emphasis will shift in coming years to determination of ocean circulation characteristics, which influence such practical matters as fish production, ship design, ship routing, storm and iceberg avoidance and climate changes. Under its TOPEX (Topography Experiment for Ocean Circulation) program, NASA plans to develop an advanced sea-monitoring satellite for launch late in this decade.

Of all the practical applications of space technology, the one with the broadest potential for Earth benefit is materials processing in orbit. Orbital processing —or space manufacturing—allows production of a great range of items not producible on Earth because of the adverse effects of gravity and air. In space there is no atmosphere and virtually no gravity; since there is a minuscule gravitational effect, scientists prefer the term "microgravity" to "zero gravity," but for practical purposes orbital operations can be considered gravity-free.

The most notable advances in space processing thus far have been in the EOS program conducted by McDonnell Douglas Corporation and its EOS partner—Ortho Corporation, a division of Johnson & Johnson—in cooperation with NASA. EOS stands for Electrophoresis Operations in Space. In the medical/pharmaceutical field, electrophoresis is a widely-used process involving electrical stimulation of a biological substance to separate the constituents of a mixture. It is used, for example, in blood tests—but not in pharmaceutical production because only a very small amount of material can be extracted at one time.

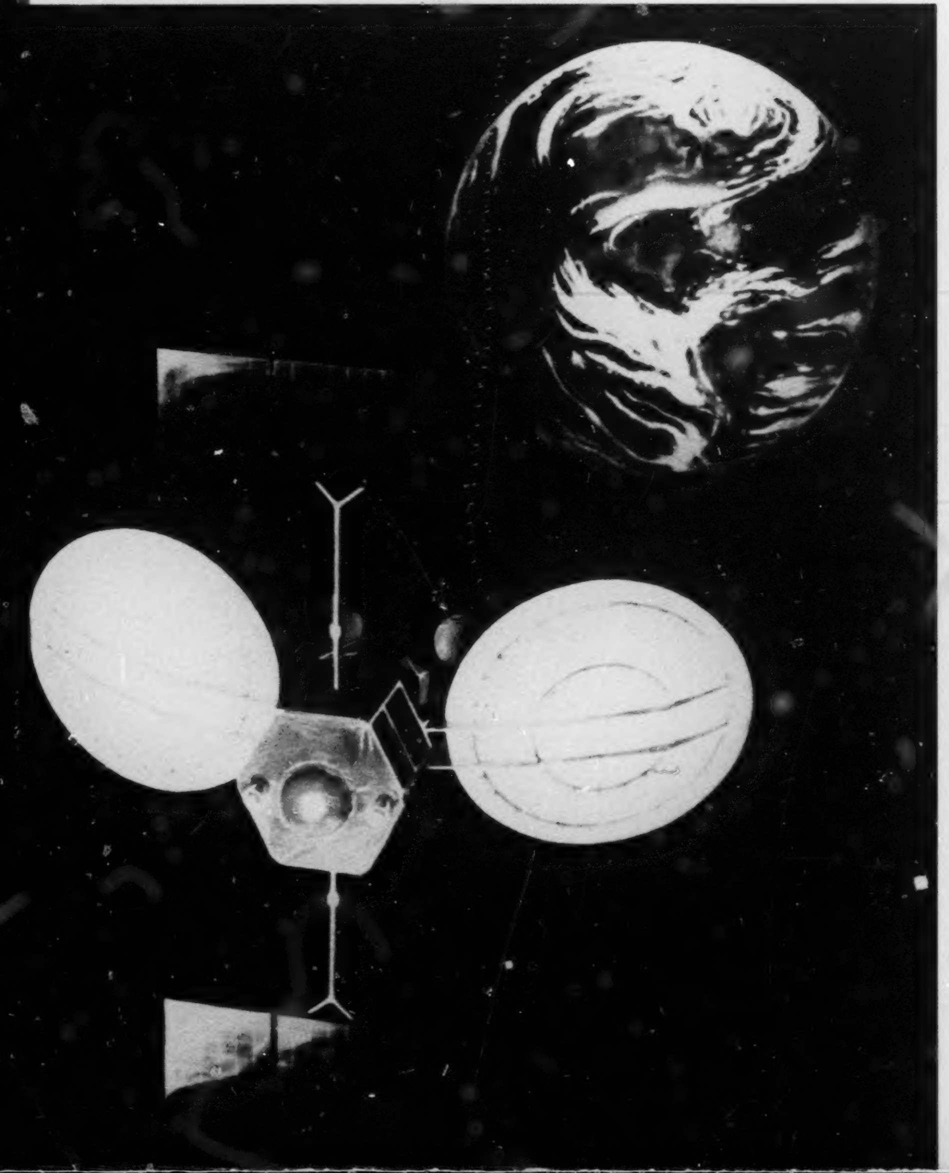
In Shuttleborne tests, the automatic EOS equipment demonstrated that it can produce more than 400 times the amount of material that could be extracted from similar Earth processing. Additionally, there are indications that the absence of gravity can increase the purity of the processed material as much as five times. This combination of vastly increased output and much improved purity may open the door to an entirely new family of space-processed pharmaceuticals for more effective treatment of disease.

The rapid advance of EOS technology suggests that McDonnell Douglas/Ortho could be ready to start pharmaceutical production in this decade. The question is what to use as a manufacturing facility; manufacturing operations will require more time in orbit and more working area than the Space Shuttle can provide. The manufacturing facility can be an unmanned, free-flying, Shuttle-tended spacecraft but, since human supervision would greatly enhance processing efficiency, the optimum factory is a human-habitable module aboard the space station NASA is planning.

Pharmaceutical production is only one of many possibilities. Orbital processing offers potential for producing a wide range of materials with properties vastly superior to similar Earth products, for example, stronger, lighter and far more temperature-resistant metallic alloys for a multitude of applications, or silicon crystals with enormously improved electrical properties for such applications as computer memories, solar cells, lasers, optical communications and many types of industrial and scientific instruments. Orbital operations also offer the interesting possibility of processing certain materials that demand extreme purity—glass for lasers or optics, for example—without use of a processing container; the materials would be melted, shaped and solidified while they float freely in space and the resultant product would be extraordinarily pure due to elimination of container-caused contamination. In a lengthy series of Shuttle tests already under way, NASA is exploring these and other possibilities.

Studies show that there are about 500 materials that could be greatly improved through orbital processing, and there are some 250 companies interested. So far only a few are actually engaged in research projects; one major reason is a reluctance to invest due to uncertainty as to future availability of space manufacturing facilities. A government commitment to development of a space station with manufacturing modules could provide the impetus to a new wave of the industrial revolution.

With the Advanced Communications Technology Satellite, planned for 1988 launch, NASA will test new ways of expanding communications satellite capabilities to forestall a possible space communications logjam in the 1990s.



In the past quarter century, we have undergone a revolutionary transformation in space technology. We need only compare the small and primitive Explorer 1, America's first satellite, to the sophisticated, manned and reusable Space Shuttle to grasp this fact. Today's Shuttle is but one element in a large and growing family of space applications, each of which has provided numerous benefits to mankind. Military space systems have helped to secure the peace and developments in the civilian and commercial sector have led to increased farm production and to greater efficiency in business practices.

In the years ahead, space holds the promise of improving the human condition further. But this can occur only if we develop the ability to better manage this technology. The evidence to date, however, suggests that space technology is progressing at a greater speed than man's ability to manage it; while technology continues to mature, our management methods have not. As I see it, there remain at least two major areas where policy has yet to catch up with the requirements posed by space systems and their applications.

Managing International Competition

Telecommunications satellites comprise a critical element of U.S. interests in space. Our ability to communicate internationally has a direct bearing not only for defense but also for U.S. foreign and economic interests.

A recent Commerce Department study, completed at the request of the Senate Commerce Committee, documents long-range problems as the United States adapts its international telecommunications policies to a changing political and technological environment. This study emphasizes several significant problems, including:

—a trend towards the politicization of international telecommunications organizations, where the focus on extraneous disputes, such as the Middle East situation, has led to the neglect of pressing telecommunications problems;
—a growing unsympathetic attitude towards U.S. needs and interests by other member nations of international telecommunications bodies;
—an inability of U.S. policy-making agencies to meet this challenge through effective policy-planning and coordination.

Americans communicate with other nations in one of two ways: through undersea cables or geostationary satellites. Intelsat, jointly owned and operated by 108 countries, governs international satellite system operations. In 1965, NASA launched the first international communications satellite for Intelsat. This satellite provided 240 voice circuits. In the last two decades, this technology has advanced rapidly. The Intelsat satellite launched in 1981 has 12,000 voice circuits and two color television channels. A new satellite scheduled for 1986 launching will provide 36,000 voice circuits. Unfortunately, the governing organizations have not advanced as rapidly or as efficiently as the technology they govern.

The International Telecommunication Union (ITU), with 157 member nations, meets regularly to determine orbital space assignments and radio frequency spectrum allocations. As more nations have access to sophisticated satellite technology, the demand for spectrum allocations increases. There is a growing conflict between developing nations, which predict a future increased spectrum need, and post industrial nations like the United States, which already have a growing and immediate need for additional spectrum space.

As the Commerce Department study points out, the ITU has become increasingly politicized as a result of its one-member, one-vote policy. Recent ITU conferences have shifted focus from legitimate communications matters to a stalemated debate on unrelated foreign policy issues. In the midst of this turmoil, the United States' interests may be slighted.

For example, last year the Federal Communications Commission authorized the development of direct broadcast satellites. This new broadcast service promises new communications potential, particularly for remote rural communities. DBS transmits a signal directly to a small Earth station located in a backyard or on the roof of a building. It is not dependent on a cable wire or a telephone pole.

However, DBS requires specific spectrum allocation—to be determined by the ITU. Here is an example of a technology available for immediate use in this country, but its development is dependent on the decisions of an international forum which is increasingly hostile to U.S. interests.

In the meantime, U.S. policymakers appear slow to develop a coordinated federal posture for these international conferences. Thirty western nations met in Geneva this spring and summer to devise a plan for DBS spectrum use. Recent Congressional committees have heard testimony critical of past and current conference preparations. The head of the U.S. delegation to the ITU conference last fall

described policy preparations as inadequate and suggested that the United States take seriously the need to prepare a thorough and long-range plan for advancing our international telecommunications interests. The Commerce Department study makes similar suggestions.

Failure to correct this situation will seriously weaken U.S. leadership in this vital area. As a first order, the Congress and the Administration must examine the current policymaking structure and act quickly to make those changes that will make the United States an effective force in meeting this challenge. Our nation has the technological strength to hold its own in space. What is needed is an effective policy to back this up. Absent a coordinated approach at the federal level and a concerted effort to work, within existing or new international structures, we cannot provide the American public with the best communications system on earth.

Protecting the Common Good

As satellite technology matures, government should look towards the private sector to manage a larger share of space activities. While this rule makes sense in general, we must assure that its specific application serves the public interest. We face this dilemma with regard to the future of meteorological satellites and Landsat remote sensing satellites. Decisions now under review by the Administration could affect the lives of thousands of workers, billions in tax dollars, the balance of payments and national security.

Since the Administration's decision to commercialize our weather and land observation satellites, the proposal has come under close scrutiny in Congress. The commercialization issue is not a new one. I have been following it for a number of years, contacting study groups and advisory board members, submitting testimony and expressing my concerns about the possible ramifications of the transfer. It took a Presidential announcement about selling the satellites to bring the issue to the level of attention it has received recently.

In recent years, I have outlined and often reiterated my concerns over subsidy costs, monopolies, service to the public, employment and defense related problems with the transfer proposals. The numerous studies that addressed these considerations are in close harmony in their findings. This is what they have to say:

- *Subsidy costs.* The private sector market is not sufficiently developed to support the transfer. In fact, the proposal will cost the government $800 million more than it currently plans to spend over the next 10 years. A government study states that "there is no clear policy or financial benefit to be realized."

- *Monopolization.* There is no doubt that total transfer to a single corporation would result in a monopoly. The studies point out that creation of a single, government subsidized monopoly (as is proposed) would be against U.S. economic philosophy. One study states that "commercialization *now* could inhibit the free market process."

- *Public service.* Portions of the weather information that we now receive free would have a price tag on it. The U.S. taxpayer has already paid for these services. I think it would be unfair to let a corporation charge a second price.

- *Employment.* It is possible that many government employees would lose their jobs as a result of commercialization. Although it is true that some of these positions would be replaced in the private sector, there would almost definitely be a net decrease in employment. It would be hard to justify a proposal that eliminates jobs, costs the government additional money, and hands ready-made monopolies over to a single corporation.

- *National Security.* The Defense Department is seriously concerned that a transfer could jeopardize U.S. security interests. For instance, meteorological data is vital for planning force deployments, war planning and intelligence. These security considerations argue for continued government control of weather forecasting capabilities.

The evidence indicates that we are not yet ready to commercialize our land and weather satellites. Still, a decision to commercialize has been made. As someone who has been actively involved in this issue for many years, I believe that a reassessment is in order.

If the private sector could operate the satellites in a true free market atmosphere, if there are, indeed, government savings; and if we can continue to provide the same level of service that the American people deserve, then we have an entirely different and much more acceptable package than is before us today. But I see none of those elements in any of the current commercialization proposals. Unless there is some new and startling evidence that has escaped me, I will continue my fight against this transfer.

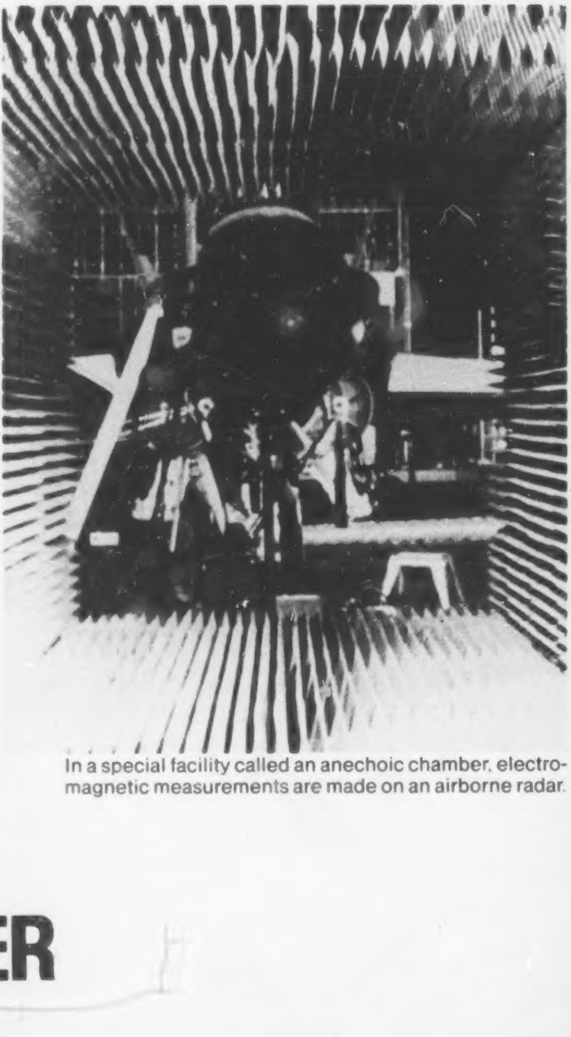
U.S. SPACE POLICY:

THE NEED FOR NEW DIRECTIONS

By SENATOR LARRY PRESSLER

Elected to the Senate in 1978, Republican Larry Pressler, 41, is senior Senator from South Dakota. He is a member and subcommittee chairman of the Senate committees on Foreign Relations; Commerce, Science and Transportation; Small Business; and the Special Committee on Aging.

Close teamwork between Navy and contractor personnel is the hallmark of the Naval Air Test Center, where new aircraft—such as the McDonnell Douglas F/A-18A Hornet pictured—undergo development testing.



In a special facility called an anechoic chamber, electromagnetic measurements are made on an airborne radar.

MAKING HISTORY AT PAX RIVER

By LAURA OVERSTREET

Sixty miles southeast of Washington, D.C., on a peninsula that juts into the Chesapeake Bay, aerospace contractors are working side by side with naval engineers and pilots to advance the state of the art in naval aviation.

The degree of sophistication and the importance of activity at Patuxent River Naval Air Test Center belie the tranquility of an area only seven miles from the site where the first Maryland settlers landed in 1634.

At Pax River history is still being made.

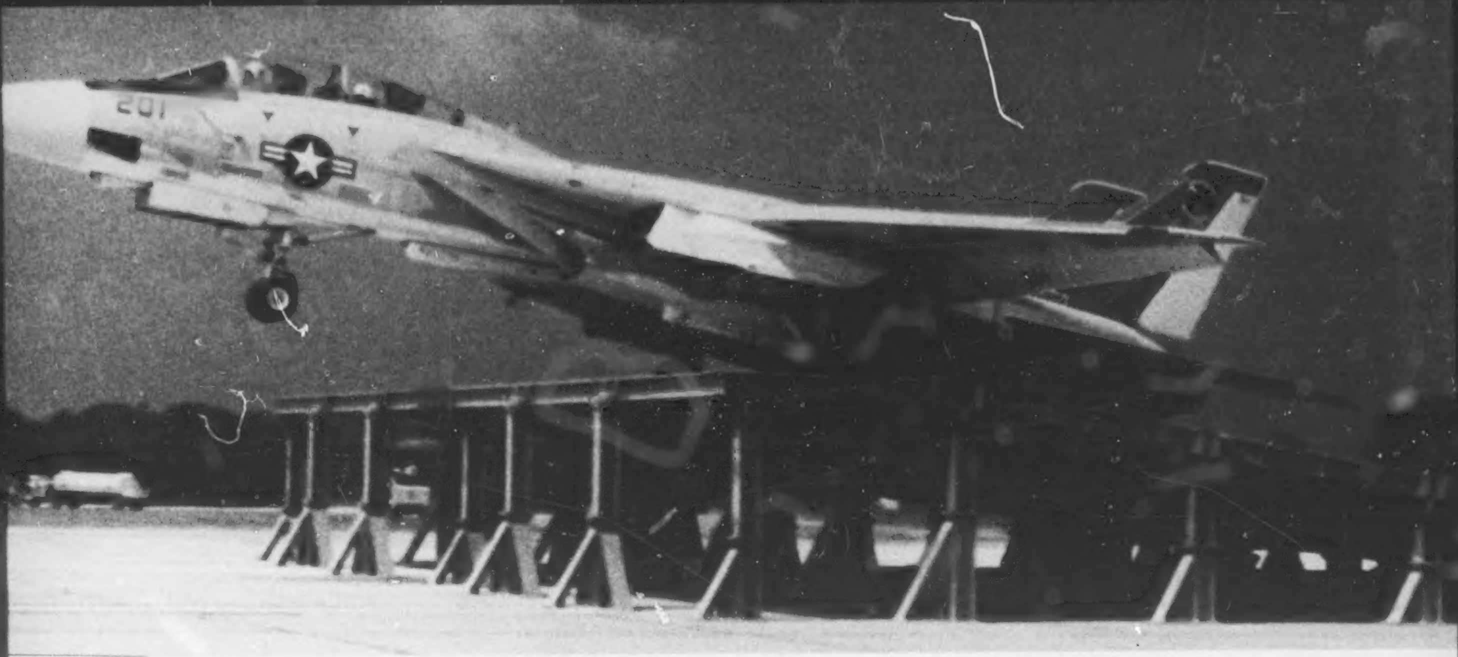
More than 500 test projects are concurrently underway on an inventory of 100 aircraft representing 30 different types in 50 differing configurations. They include fighter, attack, trainer, patrol, early warning, electronic warfare and rotary wing aircraft that serve in flying testbed, chase, target, tanker or search and rescue roles. In addition to these test planes, the airfield accommodates more than 40 operational aircraft. The mission at Pax River is testing and evaluation (T&E) of some of the nation's most sophisticated aircraft and systems.

Opened in 1945, the Naval Air Test Center has operated cooperatively with the aerospace industry since 1978 under the "single site" concept, wherein contractors rent aircraft hangars and test facilities from the Navy and conduct their own testing simultaneously with Navy evaluations of the same systems, exchanging information and eliminating redundancies. The results are savings in time and money for both the Navy and its contractors and a system of checks and balances leading to improved equipment.

At least twenty-two member companies of Aerospace Industries Association have on-going projects at Patuxent River. These include full-scale development of the McDonnell Douglas AV-8B Harrier II and follow-on test and evaluation and fleet support projects on the McDonnell Douglas F/A-18, Sikorsky SH-60B LAMPS Mk III, Grumman E-2C, Grumman A-6E and EA-6B, Lockheed P-3C, Lockheed S-3A, Grumman F-14A, McDonnell Douglas F-4, and the Sikorsky SH-3, Bell UH-1, Boeing Vertol H-46, and Sikorsky CH-53E helicopters.

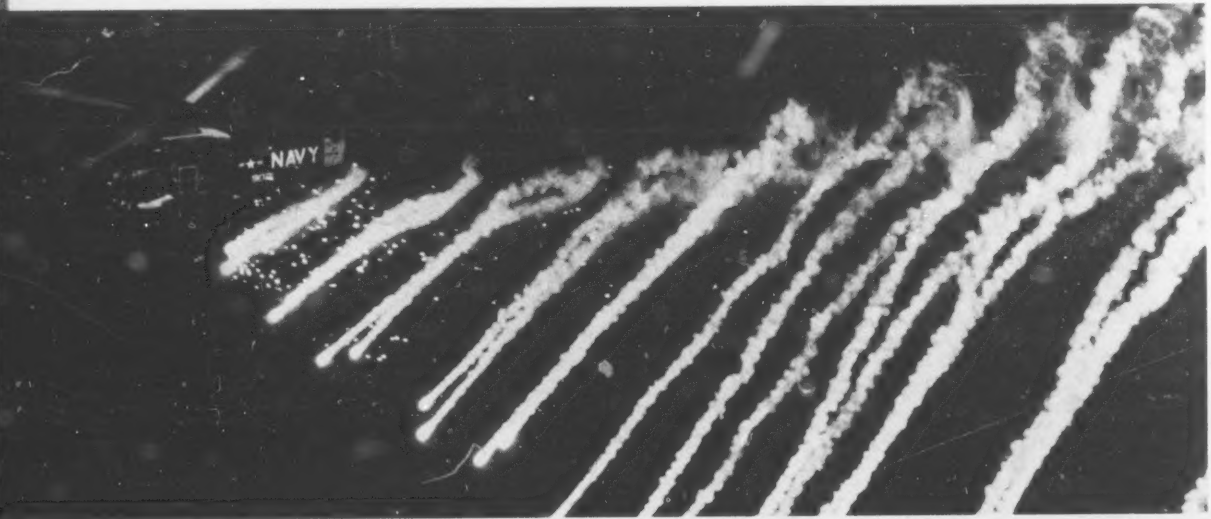
The rigors of the naval aviation mission require strict specifications. The world of the naval aircraft carrier offers a potentially hostile physical environment to the sophisticated aircraft operating from its decks. Electrical components for carrier aircraft must be small, lightweight units which consume little power and have sufficient reliability to operate hundreds of hours without malfunction, even under unusual stress. These units must be readily repaired, with the help of unobstrusive built-in test circuitry, and rugged enough to withstand the shock of catapult launches and arrested landings.

Such rigid requirements demand a close cooperative relationship between



A Grumman F-14A Tomcat leaps from a ramp elevated nine degrees in a test to determine feasibility of "ski jump" takeoffs for conventional jets.

A Kaman SH-2F Seasprite dispenses flares in an electronic countermeasures test.



A Lockheed P-3C Orion drops a lightweight torpedo in a separation test.

The Naval Air Test Center's Range Computation and Control System permits air controllers to pinpoint the positions of a large number of aircraft operating in the test range.

contractors and their Navy client. This relationship begins—long before the Pax River phase—with a mission requirement and a concept of what is needed to fulfill that requirement. It continues until the life cycle of the system is complete and the system no longer meets the mission requirement. The interim is a constant process of evaluation and improvement.

To find a source to build the system that will meet the mission requirement, the Navy Contracting Office sends out a Request for Proposal, or RFP. In effect, the RFP states that the Navy needs a certain piece of equipment that will meet specifications of size, range, speed, durability, and other details. RFPs are distributed to companies on a bidder's list and published nationwide in the Commerce Business Daily, a government publication.

Aerospace companies may respond with offers to meet the need. The Navy selects those that seem most likely to fill the requirement and requests further information. From the responses, the Navy may choose several to receive research and development contracts for building prototypes of the system under consideration. Once the prototypes have been built, a flyoff is held. The Navy eventually selects one system for full-scale development under Navy funding. In the case of aircraft, perhaps 10 planes will be hand built; these 10 are assigned to Pax River and the T&E process begins.

Most development aircraft are specially equipped to test specific requirements. One or more will be equipped to function as a fully mission-capable system. Both contract and Navy pilots fly the aircraft, expanding its performance envelope to the limit and beyond, in order to determine the full potential of the airplane and its components.

Project assignments may include tests on airborne radars, navigation and digital display systems, electronic warfare systems, on-board test equipment, and electro-optical sensors. Also tested are such ancillary segments of the performance envelope as engine airstarts, shipboard launch and recovery, in-flight refueling, armament carriage/separation and aircraft gunfiring.

It is here that communication between pilot and engineer, contractor and naval personnel is so important. Minor engineering or structural changes to test planes can be made on-site at Patuxent River, saving time and money, and incorporated simultaneously into production models at the contractor's plant. Major modifications, quickly identified through exchange of information, are performed at the aircraft or component manufacturer's production facility.

Test and evaluation goes beyond the development aircraft at Pax River. From operational T&E squadrons at Point Mugu and China Lake, California, and at Patuxent River, operational test pilots and engineers put production models through realistic operational scenarios, using operational maintenance support. Wartime tactics are developed to exploit the fullest potential of the aircraft's mission. Operational T&E never ends. Once the aircraft is in the fleet and functioning on carriers around the world, performance monitoring provides feedback to the engineers at Patuxent River, where testing and modification continues.

Pax River testing is monitored by the latest in computer equipment. The Center's real time data telemetry station receives up to 512 independent data measurements from each of four aircraft operating simultaneously; each of the four channels samples data measurements at rates up to 50,000 times per second and each can operate from airborne recorded tapes or telemetered data at a receiving rate of 1.2 million bits per second. The data is converted to corrected engineering units, subjected to flight safety checks, then displayed in real time to project engineers on one of four separate project engineering stations. The telemetry system monitors not only the vital signs of the aircraft under test but also tracks the performance of on-board systems.

While telemetry looks at what is happening inside the flying aircraft, the Chesapeake Test Range at Patuxent River provides exact positioning information on the aircraft through a Range and Computation Control System (RCCS). Resembling a Star Wars command and control center, the RCCS processes data in real time from a variety of sensors, including radar, theodolite and laser tracking systems, and displays the data on cathode ray tubes, or on a six-by-six foot four-color screen, or on mechanically-controlled printers and plotters. During a range test, such displays—manned by members of the Range Computation and Control Section—provide information for vectoring and controlling individual missions of up to four aircraft each. The large screen display provides for overall range coordination and safety analyses for as many as sixteen aircraft.

Other facilities at Patuxent River include a comprehensive avionics evaluation laboratory; a ground based TC-7 steam catapult; a full MK-7 arresting gear to test an aircraft's suitability for carrier operations under controlled conditions; and laboratories for design, fabrication, calibration, and testing of a wide variety of specialized airborne test instrumentation. Of the some 10,000 people who work at the Naval Air Test Center, nearly 3,000 worked for aerospace contractors.

There is another major activity at Pax River—the U.S. Naval Air Test Pilot School, one of only four pilot schools in the free world. Here in the 1950s and early '60s, history was made as Navy test pilots soon to be touched by destiny put their machines through the rigors of testing without today's sophisticated computerized monitoring. On their way to the space age, test pilots such as John Glenn, Al Shepard, Scott Carpenter and Pete Conrad hung their aircraft over the edge of technology high above Patuxent. Housing areas at Pax River bear such names as Glenn Vista, Shepard Court, Conrad Heights and Carpenter Park, reflecting earlier days of aerospace research and serving as historical backdrop to the challenges still being met at Pax River.

National Benefits of Aerospace Exports

In all the years of this century, the United States never experienced an international trade deficit until 1971. Since then, U.S. trade has been in the red 10 of 12 years and the amount of the annual trade deficit has been growing alarmingly. Last year it topped $35 billion, a record but a short-lived one; a higher deficit is already assured for 1983 and some forecasters think this year's figure might be more than double last year's. That's a nutshell summary of a U.S. trade picture that is causing deep concern in government and industry circles.

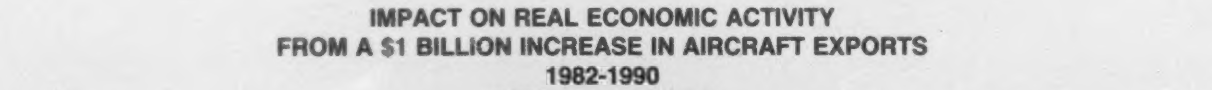
A bright spot amid the gloom has been the trade performance of certain high technology industries, in particular the aerospace industry, which recorded a trade surplus of $11.2 billion last year. But, says a report by Aerospace Industries Association's Aerospace Research Center, although the 1982 aerospace trade balance constituted a very substantial contribution to the U.S. economy, it nonetheless represented an inflation-adjusted decline of about 20 percent—and that "must be seen as a warning."

Entitled *National Benefits of Aerospace Exports*, the report states "there is a real possibility that the (aerospace) industry could yet be undercut—technologically and competitively—in world markets, as were other basic U.S. industries. Because high technology is one of the United States' largest remaining areas of competitive advantage in world trade, significant declines in aerospace trade— notably aircraft trade, the largest component of industry exports—would have serious implications for the economy and the nation as a whole."

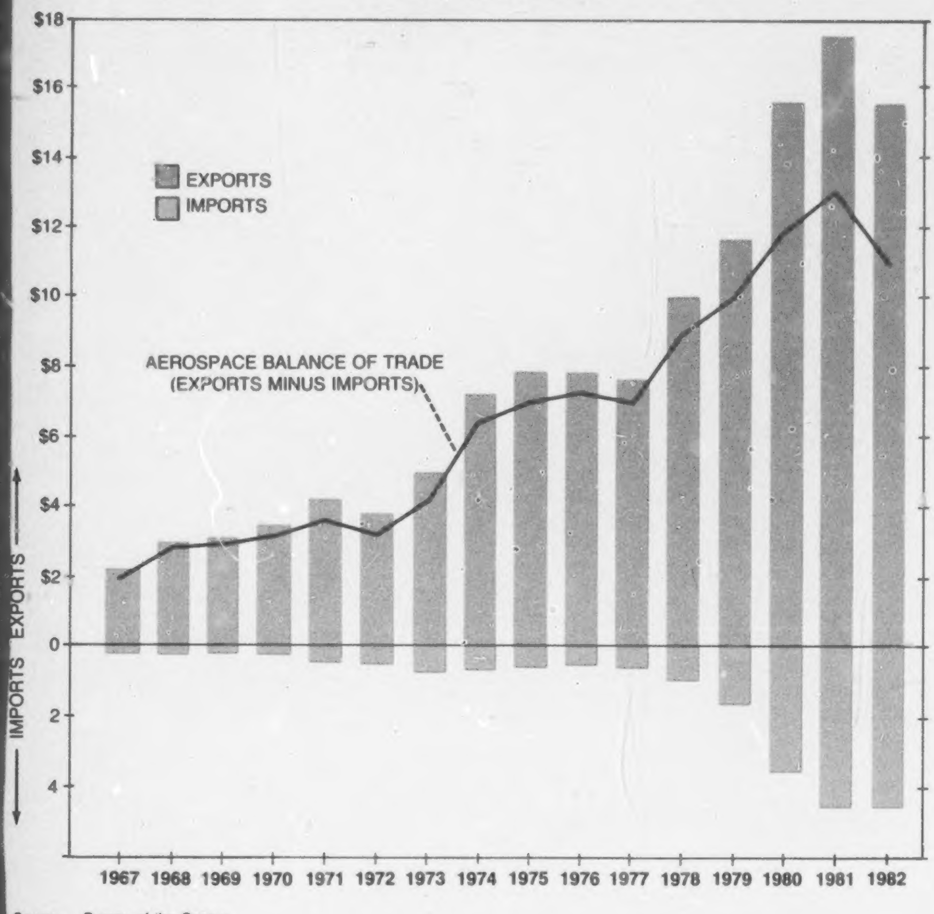
Much of the 1982 aerospace trade decline—after several record-setting years—was attributable to the world recession, high interest rates, the financial problems of the world's airlines, and similar problems experienced by potential purchasers of general aviation aircraft and helicopters. But there were other contributing factors, among them increasingly aggressive competition from foreign manufacturers who enjoy the full support of their home governments. The report underscores the fact that "aerospace imports are of particular concern because their growth rate has been steeper than that of exports." In 1978, the value of U.S. aerospace imports was well below $1 billion; last year it was more than $4.4 billion.

The combination of greater competition and other trade-influencing factors

This chart shows how a $1 billion increase in aircraft exports would generate a $6.5 billion gain in the Gross National Product over a nine-year span. It would also add more than 44,000 job-years in the aerospace industry and 104,000 job-years in other U.S. industries.



Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corporation, for the Aerospace Industries Association, June 1982.



AEROSPACE EXPORTS, IMPORTS, AND TRADE BALANCE
(Billions of Current Dollars)

Source: Bureau of the Census

Aerospace exports and trade balance grew impressively from 1967 until last year's decline. But U.S. aerospace imports have increased more rapidly in recent years.

is substantially impacting the U.S. aerospace industry at a time when it has invested billions in development of new-generation aircraft. "The United States must recognize this fact," says the report, "and respond appropriately to preserve the strength of a vital but potentially vulnerable (aerospace) industry." It adds these conclusions:

"In order to compete in an increasingly aggressive world trading environment, the United States must build on its competitive strengths, among them high technology exports. Aerospace products are a major component of that high technology advantage; the industry exports about a third of its product and the benefits to the U.S. economy, both direct and indirect, are significant...

"As foreign aircraft producers gain competitive strength, it becomes especially important to assess the returns from exports and to consider and take steps to strengthen the network of practices and policies that must assist aerospace and other industries to maintain their place in the market." Among steps that might be taken, the report suggests a review of antitrust laws for their impact on U.S. joint ventures and a need to explore tax and other incentives favoring R&D and innovation, toward effecting a substantial increase in U.S. R&D expenditures.

Continuing U.S. high technology competitiveness is important to economic growth, national security and employment. To quantify the extent of such benefits, AIA commissioned an independent and objective study—performed by Chase Econometrics/Interactive Data Corporation—of the impact of aircraft exports on the U.S. economy. The basic assumption of the study was a $1 billion increase in aircraft-related exports in 1982. That initial $1 billion, the study group found, would add 44,200 full-time equivalent (FTE) jobs in the aerospace industry; as a result of supplier sales and economic multiplier effects, the total impact would be 148,400 FTE man-years over the period 1982-1990.

Additionally, the initial $1 billion would generate a $6.5 billion increase in the Gross National Product, the largest increment of gain ($3 billion) reflecting increased consumption resulting from direct and indirect wage earnings. It would also boost government revenues through personal and corporate income taxes, social security receipts, state and local receipts, and it would contribute to reduced unemployment compensation payments and lower government interest expense. Over the nine-year period 1982-1990, the total reduction in the federal deficit, including interest expense, would be $3.7 billion in current dollars or $2.4 billion in 1982 dollars.

Other key benefits would accrue from an increase in aircraft exports:

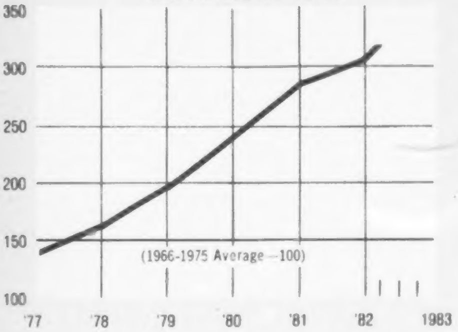
- Aircraft are high-value items, therefore especially important to the U.S. balance of trade.
- An existing large, well-trained high-technology labor force and well-equipped civilian aircraft manufacturing facilities represent national assets that would provide insurance in time of national emergency by enhancing "surge" capability, the industry's ability to step up production rapidly.
- Large-scale sales to foreign customers allow spreading aircraft production costs over a larger number of units, reducing unit cost and directly benefiting U.S. airlines and the U.S. government.
- R&D requirements for new aircraft, funded in part through export sales, generate technological advances that often find spinoff application in product areas other than those for which the technology was originally developed; such technology conversions create new product lines, sometimes whole new industries, with attendant benefit to the U.S. economy.
- A particularly important form of spinoff is civil/military "crossover," the sharing of knowledge between the industry's civil and military manufacturing segments. In the past, R&D crossover usually went from the military to the civil segment; today, the flow is more often in the reverse direction, especially from civil to military aircraft. Such crossover saves the taxpayers money while contributing to technological advancement in military systems.

Copies of *National Benefits of Aerospace Exports* are available from the Aerospace Research Center, 1725 DeSales Street NW, Washington, D.C. 20036.

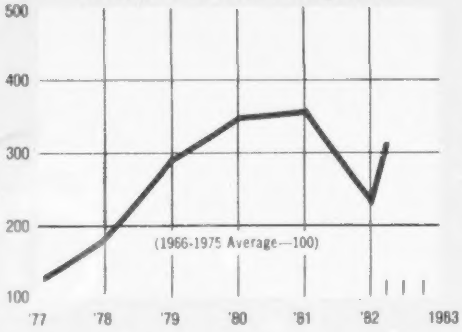
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

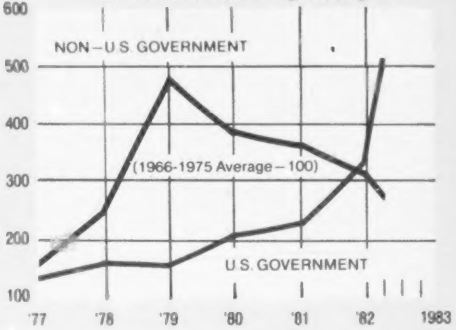


Value of Civil Aircraft Shipments[r]



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD**	LATEST PERIOD 1st QTR. 1983
AEROSPACE SALES: TOTAL	**Billion $**	**Annually*****	**24.2**	**70.4[r]**	**74.1[r]**	**77.1**
(as reported by the Bureau of the Census)	**Billion $**	**Quarterly**	**6.1**	**16.7**	**20.4[r]**	**19.7**
AEROSPACE SALES: TOTAL	***Billion $***	***Annually*****	***25.6***	***35.4[r]***	***35.8[r]***	***36.8***
(in constant dollars, 1972=100)	***Billion $***	***Quarterly***	***6.4***	***8.2***	***9.7[r]***	***9.2***
AEROSPACE PRIME CONTRACT AWARDS: TOTAL	**Billion $**	**Quarterly**	**5.8**	**19.4**	**24.0[r]**	**27.1**
U.S. Government	**Billion $**	**Quarterly**	**4.1**	**11.0**	**17.2[r]**	**21.1**
Other Customers	**Billion $**	**Quarterly**	**1.7**	**8.4**	**6.8[r]**	**6.0**
BACKLOG (Major Aerospace Mfgrs): TOTAL	**Billion $**	**Quarterly**	**28.6**	**96.0[r]**	**103.6[r]**	**111.7**
U.S. Government	**Billion $**	**Quarterly**	**15.9**	**45.5**	**58.4[r]**	**68.6**
Other Customers	**Billion $**	**Quarterly**	**12.7**	**50.5[r]**	**45.2[r]**	**43.1**
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	**Million $**	**Quarterly**	**2,712**	**8,747**	**8,850**	**11,045**
Aircraft Procurement	**Million $**	**Quarterly**	**1,986**	**7,015**	**6,604**	**9,045**
Missiles Procurement	**Million $**	**Quarterly**	**726**	**1,732**	**2,246**	**2,000**
Aerospace Outlays: TOTAL	**Million $**	**Quarterly**	**2,405**	**4,844**	**6,642**	**6,197**
Aircraft Procurement	**Million $**	**Quarterly**	**1,741**	**3,888**	**5,502**	**4,990**
Missiles Procurement	**Million $**	**Quarterly**	**664**	**956**	**1,140**	**1,207**
NASA RESEARCH AND DEVELOPMENT						
Obligations	**Million $**	**Quarterly**	**780**	**1,688**	**1,515**	**1,778**
Expenditures	**Million $**	**Quarterly**	**789**	**1,155**	**1,289**	**1,299**
EXPORTS						
Total (including military)	**Million $**	**Quarterly**	**1,038**	**4,153**	**4,151**	**4,586**
New Commercial Transports	**Million $**	**Quarterly**	**345**	**1,410**	**688**	**1,630**
EMPLOYMENT: TOTAL	**Thousands**	**End of Quarter**	**1,166**	**1,178**	**1,150**	**1,146**
Aircraft	**Thousands**	**End of Quarter**	**650**	**626**	**601**	**582**
Missiles & Space	**Thousands**	**End of Quarter**	**114**	**125**	**130**	**139**
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	**Dollars**	**End of Quarter**	**4.38**	**10.93**	**11.77**	**11.64**
PROFITS (after tax) BASED ON SALES						
Aerospace	**Percent**	**Annually*****	**2.7**	**3.7**	**3.3[r]**	**3.3**
	Percent	**Quarterly**	**2.7**	**3.2**	**3.1[r]**	**3.2**
All Manufacturing	**Percent**	**Annually*****	**4.8**	**4.5**	**3.5**	**3.3**
	Percent	**Quarterly**	**4.8**	**3.8**	**2.8**	**3.2**

Source: Aerospace Industries Association

*1966-1975 quarterly averages are computed as one-fourth of annual averages.

**Preceding period refers to quarter preceding latest period shown.

***Annual data are computed as the sum of the previous four quarters.

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AEROSPACE INDUSTRIES ASSOCIATION
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The 1982/83
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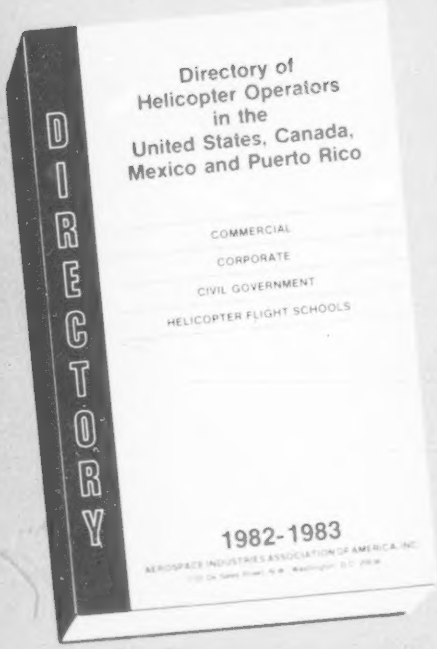

Directory of Helicopter Operators in the United States, Canada, Mexico and Puerto Rico
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1982-1983
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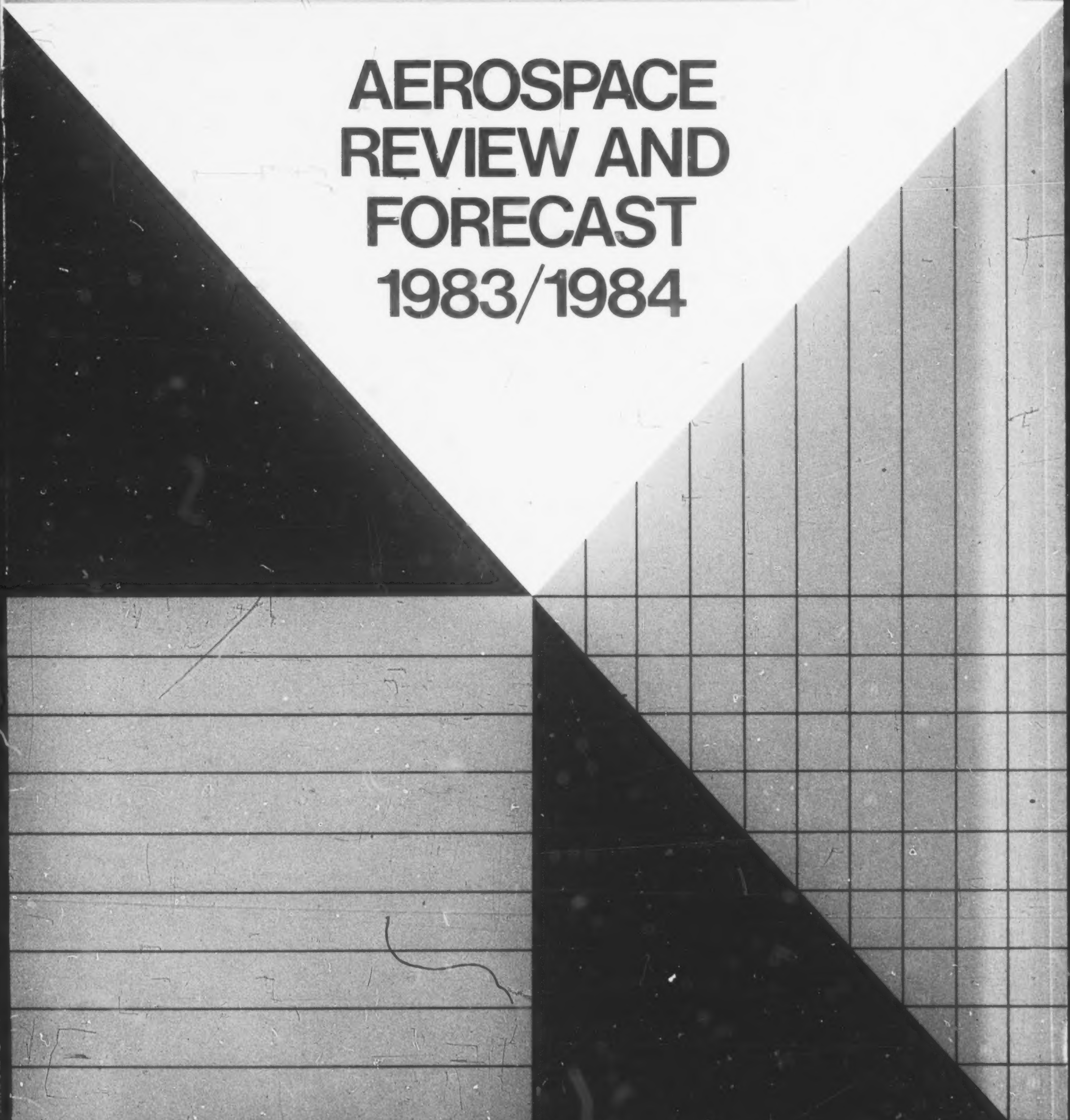
AEROSPACE REVIEW AND FORECAST 1983/1984



Notable views of notable people on aerospace matters...

General James P. Mullins, *Commander, Air Force Logistics Command, in an address to a meeting of the National Security Industrial Association in Los Angeles, California:*

"We in American society are great ones for casting blame when things go wrong—even when things aren't really all that wrong, and even when the blame is substantially unjustified. We also have the unfortunate tendency to attack the very foundations of the life and happiness we enjoy, often without rational or well-defined reasons in mind . . . In fact, this is even true for the two most essential parts of American democracy—the military and the free enterprise system. It is especially true when these two are combined into what is often disparagingly called the 'military industrial complex'. . .

"Frankly, I believe the military/defense industry complex needs more support and less criticism—especially considering that it has kept us free for over 200 years and has protected and defended much of the free world from those dark forces which have always threatened it. . .

"There's certainly no doubt in anyone's mind these days that defense is a big business in this country. But that doesn't mean defense spending is the wasteful and unproductive drain on our economy which many believe it to be . . . Americans have received the greatest benefit of all from the investment in defense they've made—after all, we haven't been attacked and we're still a free and democratic society . . . It's also important for Americans to understand that defense represents only 17 percent of our total public spending, which is down from a postwar high of 36 percent in 1955. In fact, today it represents only about six percent of our Gross National Product—less than half of what the Soviets now spend—and about 17 percent of what we spent during the height of World War II.

"There's no reason why Americans should not be proud of their military industrial complex . . . with the proper incentives, American free enterprise can produce the best material, at the lowest price, and in the least amount of time. I'm confident that . . . the American military will continue working hand-in-hand with the private sector and that together, ultimately, we'll get the job done."

James Renier, *Vice Chairman, Honeywell, Inc., in a talk to the Construction Industry Manufacturers Association in Schaumburg, Illinois:*

"As the factory of the future becomes the factory of the present, it will present a variety of questions and problems that will have to be solved . . . Two basic problems are apparent today. One is the danger of unemployment as automation threatens to eliminate jobs. The other is the displacement of workers as old skills are obsoleted and new needs take their place . . . The threat of unemployment will be greatest for those who are unable to market old skills in a new factory environment. Regardless of the level of absolute employment, this can be a serious problem for thousands. . .

"Eventually, the problem will have to be faced by management, labor and government. Management can contribute by defining carefully, and well in advance, what kind of jobs and how many jobs will open up, and which jobs will be surplussed. Labor organizations can help by preparing workers attitudinally and substantively for the adjustments required. Municipal, state and federal governments can establish educational programs for those coming into the work force and those being displaced. . .

"A broad view of the problem is necessary. We must find ways to adjust as a society, not individually. We cannot win with piecemeal efforts . . . We must gain the perspective to see how we can use automation for the good of all, not just a few."

Chalmers Johnson, *author of a definitive work on the Japanese Ministry of International Trade and Industry, as quoted in* Shadows of the Rising Sun *by Jared Taylor, published by William Morrow & Company:*

"Other nations seeking to emulate Japan's achievements might be better advised to fabricate the institutions of their own developmental states from local materials. It might suggest that what a country like the United States needs is not what Japan has but, rather, less regulation and more incentives by the government for people to save, invest, work and compete internationally . . . The United States might be better advised to build on its own strengths and to unleash the competitive impulses of its citizens rather than add still another layer to its already burdensome regulatory bureaucracy."

William H. Gregory, *editor of Aviation Week and Space Technology, in an address to the Annual Awards Banquet, Aeronautical Systems Division, Air Force Systems Command in Dayton, Ohio:*

"When internal debates in the defense community spill over into Congress or into the public prints, they lose their context. The picture the taxpayer gets of aerospace technology becomes one of complex new gadgetry that costs megabucks and won't work, and the credibility of the developer suffers.

"Congress has reacted to this misunderstanding of the development process to mandate legislatively the creation of a new independent test force. Not only is its creation a canard on the professionals who do the testing in the services now, but it imposes one more approval layer on an overstructured system—more micromanagement, not less. Well intentioned as the Congressional solution may be, it will lengthen the development cycle. Time is money and development costs will get one more ratchet upward they do not need."

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CONTENTS

2 AEROSPACE HIGHLIGHTS: 1983
By James J. Haggerty

12 AEROSPACE REVIEW AND FORECAST 1983/1984

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aerospace systems and their components.

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The Aerospace Industry: A National Asset

BY KARL G. HARR, JR.,
President Aerospace Industries Association

This issue is devoted to a review of the aerospace year just ended and a summary of the industry's future prospects. The basic conclusion to be drawn from these pages is that the industry's health has never been better and the prognosis is excellent.

And that, I submit, is a very good thing for the United States of America, because a strong aerospace industry is essential to the nation's economy and its security.

With regard to the economy, consider some of the facts listed herein. The aerospace industry employs more than 1.1 million people whose total earnings are $35 billion—and both numbers are going up. This single industry accounted for 2.25 percent of the national Gross National Product. In a year when the nation as a whole experienced a record international trade deficit, the aerospace industry recorded a solid trade surplus approaching $13 billion, offsetting to a substantial degree deficits in other industries.

The industry's development of space technology is not only contributing in great measure to expansion of our national technological base, it is also an important asset in our international competitive capability. All indications point to a boom in commercial space activity in the remaining years of this century—in communications satellites, launch vehicles and launch services, upper stage systems, commercial experiment platforms and the burgeoning new field of space manufacturing. Commercial space competition from abroad is already intense and it bids to become more so. But the U.S. aerospace industry holds a firm leadership position and it has the technological strength to maintain that position as space becomes a more significant factor in international economic competition.

The aerospace industry is the principal hardware-producing element of the government/industry defense team. The free world, with the United States in the forefront, can only answer greater Soviet weapons numbers by means of technologically superior defense systems. Therefore, our industry's demonstrated excellence in development of advanced weaponry is a vital factor in our national capability for deterrence. General James P. Mullins, Commander of the Air Force Logistics Command, recently addressed that subject: "Without the military and private industry working closely together in a free-enterprise environment, much of the technological excellence we rely upon for our survival simply would not exist—and, without much doubt, neither would we."

Having said that, it becomes necessary to point out that about two-thirds of this industry's business comes from government orders. That business is subject to the vagaries of political pressures and this is particularly true in an election year. As a result we may find our ability to produce efficiently restrained by a melange of politically inspired initiatives, from both the Congress and from the executive branch, which would impact negatively on industry's productivity. In general, these initiatives take various forms of micromanagement, whereby our government customer, more and more, is telling us not only what it wants but how to produce it.

Nevertheless, the aerospace industry indubitably must play a prominent part in America's future. It is, therefore, gratifying to report that this segment of American industry currently is financially sound, competitively strong, technologically progressive and well-positioned to meet whatever challenges tomorrow may bring. And that should be good news for all Americans.

AEROSPACE

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HIGHLIGHTS 1983

By JAMES J. HAGGERTY

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1. In June, the Air Force began flight testing the complete four-stage Peacekeeper ICBM.
2. The Army completed engineering development testing of the Pershing 2 mobile ballistic missile and deployment of the weapon in West Germany began in December.
3. The Tomahawk cruise missile was in development and production in several versions; the one pictured is the Air Force Ground Launched Cruise Missile.
4. The first Imaging Infrared Maverick, which makes possible nighttime use of the air-to-surface missile, was delivered to the Air Force in October.

DEFENSE

In a late year development, Congress approved some $2 billion for initial production of 21 Peacekeeper (MX) intercontinental missiles and provided an additional $2 billion for MX development and testing. Earlier in the year—in June—the Air Force started flight tests of the complete four-stage missile with a launch from Vandenberg AFB, California into a Pacific Ocean target area near Guam. The June flight and two others—in October and December—were pronounced successful. The Air Force stated plans for a 20-flight test series, the next four at three-month intervals in 1984; initial operational capability was scheduled for early 1987. Major Peacekeeper contractors include Martin Marietta Aerospace (assembly and test); Rockwell Autonetics (guidance and computers); Northrop (inertial guidance system); Morton Thiokol (first stage); Aerojet-General (second stage); Hercules Incorporated (third stage); Rockwell Rocketdyne (fourth stage); Avco Corporation and General Electric Company (reentry systems); Westinghouse (missile canister); Boeing (support equipment); TRW Inc. (engineering and technical support); and Honeywell Inc. (guidance and control elements).

In a related strategic weapons development, the Department of Defense initiated a systems definition program—to be completed late this year—on the tentatively-designated Small ICBM, a missile with intercontinental range weighing less than one-fourth the Peacekeeper. Full-scale engineering development was targeted for 1986, with flight testing beginning in 1988.

The Navy's Trident I sea-launched ballistic missile was in initial operational status aboard Trident-class nuclear-powered submarines and the Navy took the first steps in development of the advanced Trident 2, planned for deployment in 1989. Lockheed Missiles & Space Company, manufacturer of Trident I, was awarded the prime contract for development and production of the advanced missile; General Electric was assigned the fire control system and Westinghouse the launcher subsystem.

In September, the Army completed the 18-flight engineering development test program of the Pershing 2 mobile ballistic missile built by Martin Marietta Aerospace. Deployment of the missile in West Germany began in December.

The General Dynamics Tomahawk

cruise missile was in development and in production in several different versions, including the Air Force GLCM (Ground Launched Cruise Missile); the Navy TASM (Tomahawk Anti-Ship Missile), designed to locate and attack surface vessels; and the TLAM-N (Tomahawk Land Attack Missile-Nuclear), intended for launch from submarines or surface ships. First flight of the latter version was carried out successfully in November. European deployment of GLCMs began in December. Another version of the Tomahawk, the USAF/USN MRASM (Medium Range Air-to-Surface Missile) was terminated in August, but studies were initiated on a MRASM follow-on joint Air Force/Navy cruise missile.

The Air Force/Boeing ALCM (Air Launched Cruise Missile) was in production and in operational status. General Dynamics was selected to develop an advanced Cruise Missile intended as a successor to the ALCM.

In other 1983 missile developments,

- Certification flight tests of the USAF/USN AMRAAM (Advanced Medium Range Air-to-Air Missile)—being developed by Hughes Aircraft with Raytheon Company as a second production source—began in the fall.
- In October, Hughes delivered the first Imaging Infrared Maverick air-to-surface missile to the Air Force; the infrared system makes possible nighttime use of the weapon.
- In December, the U.S. and the Federal Republic of Germany signed an agreement for joint production and deployment in Germany of the Raytheon-developed Patriot long-range air defense system. Under the same agreement, the two countries will also produce the German-French Roland short-range air defense missile for use by U.S. and NATO forces.
- General Dynamics' RAM (Rolling Airframe Missile) was undergoing land and sea-based interception tests against target drones and supersonic missiles; tests were to continue into 1984, when a production decision is expected. RAM is a shipboard defense system intended for U.S. and NATO navies.
- The Army was conducting experimental flight tests of a Lockheed-developed ballistic missile interceptor under the HOE (Homing Overlay Experiment) program.
- In May, Hughes Aircraft started deliveries of the TOW-2, an improved version of the TOW antitank missile in Army and Marine Corps service.
- The Army's MLRS (Multiple Launch Rocket System) became operational in September and LTV Aerospace and Defense Company received a contract to produce 339 systems in the first year of a planned five-year procurement.
- The Army initiated the Small Radar Homing Interceptor Technology program with a contract to LTV Aerospace for development of a ballistic missile interceptor to be experimentally flight tested against targets simulating re-entry vehicles.

Among military aircraft developments, the first production USAF/Rockwell International B-1B bomber was nearing completion at year-end; in October, General Electric delivered the first F-101-GE-102 30,000 pound thrust turbofan engine. First B-1B delivery to the USAF was scheduled for mid-1985 and initial operational capability—a full squadron of 16 aircraft—was planned for the fall of 1986.

In other military aircraft highlights,

- The first Grumman EF-111A Raven electronic warfare aircraft were assigned to a USAF operational unit and deployment with an Air Force squadron in England was scheduled for 1984. Grumman will deliver a total of 42 EF-111As through 1985.
- The experimental USAF AFTI F-111 MAW (Mission Adaptive Wing) airplane, being built by Boeing Aerospace, neared completion at year-end. Targeted for first flight this summer, the plane features a wing whose camber—the fore-aft curve of the airfoil—can be changed in flight, a major aerodynamic "first."

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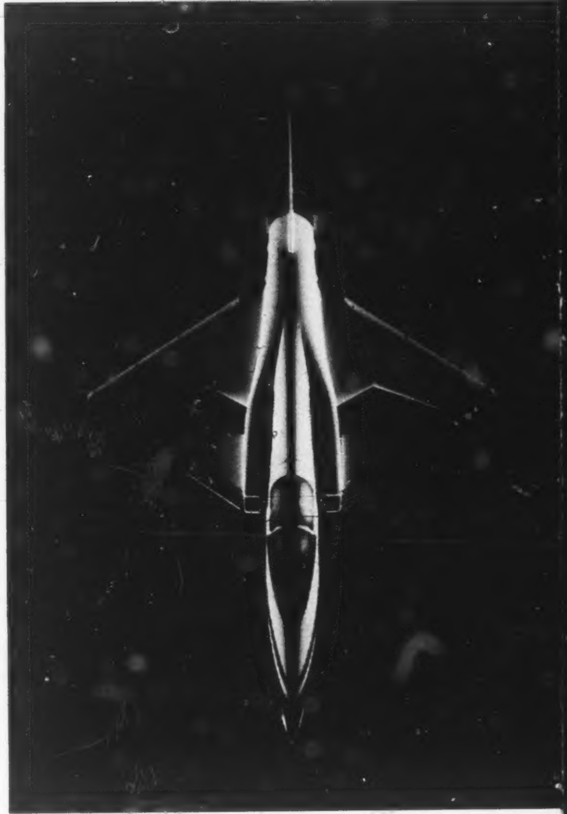

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5. The first production model of the Air Force B-1B bomber neared completion at year-end; the aircraft shown is a B-1A development prototype, externally similar to the B-1B.
6. Scheduled for first flight this summer, the X-29A forward-swept-wing research airplane was in final construction status.
7. The Navy initiated the JVX tilt-rotor VTOL aircraft program with a contract for preliminary design.
8. First of the AH-64 Apache gunships were delivered to the Army in late 1983.
9. In October, the Navy took delivery of the first Light Airborne Multipurpose System Mark III, which combines ship and helicopter (SH-60B) antisubmarine warfare systems.

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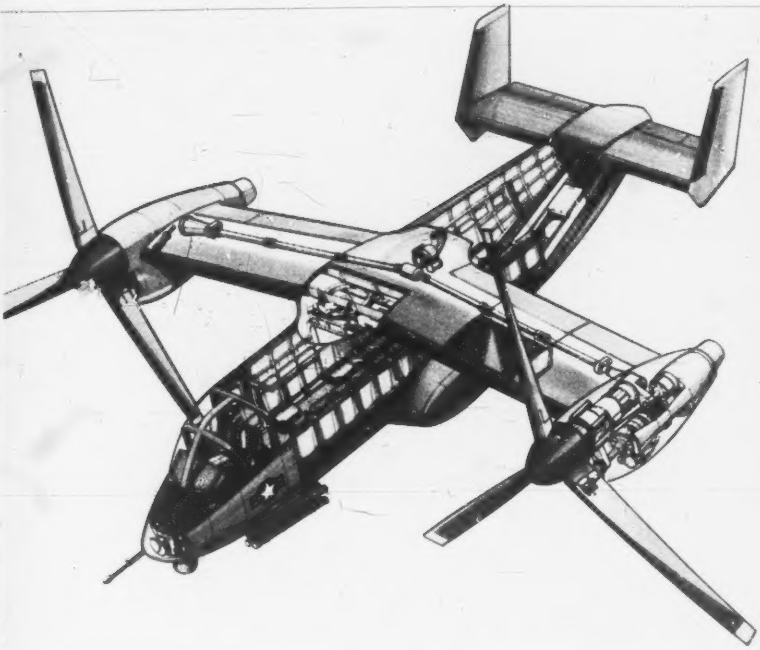

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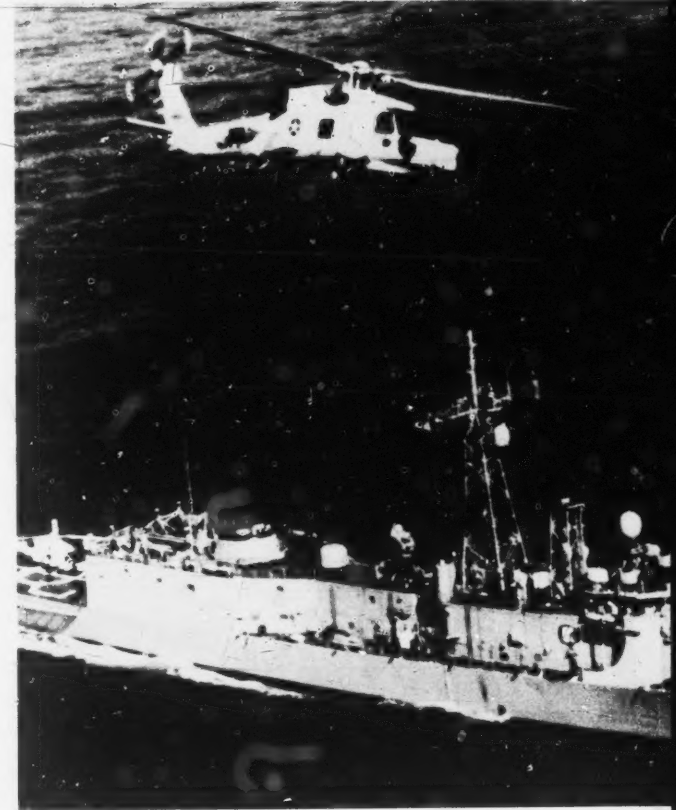

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• Also nearing completion and slated for first flight in the summer of 1984 was the Grumman-built X-29A. Developed under contract with the Defense Advanced Research Projects Agency, the X-29A features an innovative design in which the main wing is swept forward rather than rearward.

• In September, Grumman delivered the first of 11 C-20 Gulfstream III flight transports to the Military Airlift Command.

• In April, Bell Helicopter Textron and Boeing Vertol Company received a Navy contract for preliminary design of the JVX tilt-rotor vertical takeoff and landing aircraft. The schedule called for start of full-scale engineering development in June 1985, test and evaluation through 1990, initial operational capability for the Marine Corps in 1991 and operational use by the Army, Navy and USAF beginning in 1993.

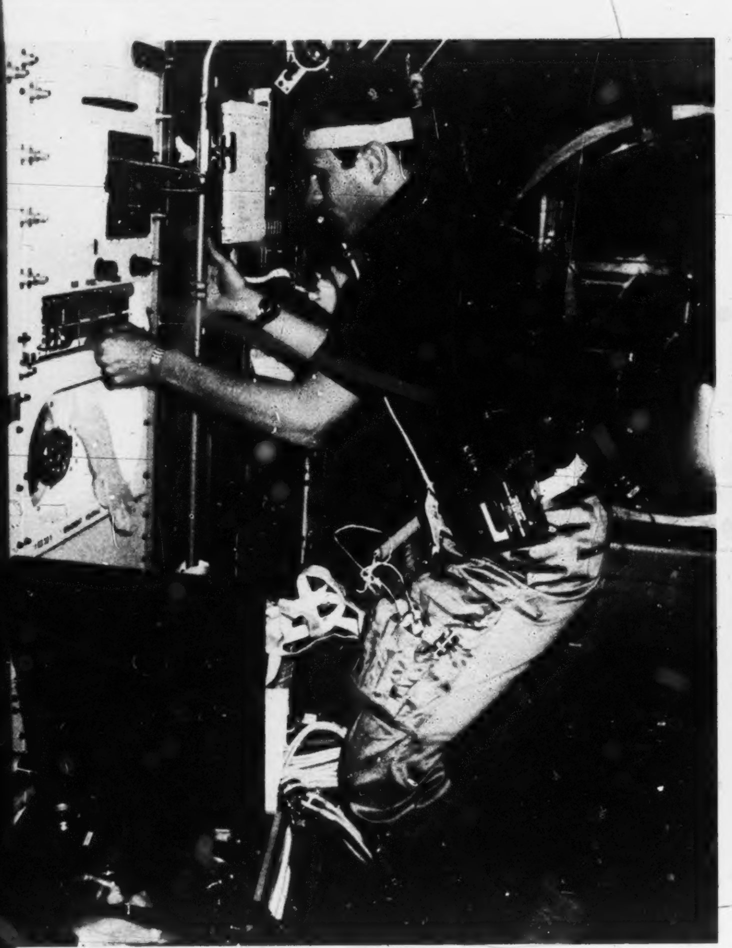
• In September, Hughes Aircraft rolled off the production line the first AH-64 Apache; two of the helicopter gunships had been delivered to the Army by the end of 1983.

• IBM's Federal Systems Division delivered to the Navy—in October—the first LAMPS (Light Airborne Multipurpose System) Mark III, which combines a ship and a helicopter (Sikorsky SH-60B Seahawk) as an integrated unit for antisubmarine warfare and anti-ship surveillance and targeting operations.

• Sikorsky neared completion on the first unit of a companion aircraft, the USAF HH-60D Nighthawk combat search and rescue helicopter, which will also have IBM avionics equipment. The HH-60D was scheduled for first flight early in 1984.

• The U.S. Marine Corps/Bell Helicopter Textron AH-1T SuperCobra made its first flight in November; a production order was expected in 1984.

SPACE



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For the National Aeronautics and Space Administration, 1983 was highlighted by the operational debut of Spacelab, the human-habitable orbital laboratory developed by the European Space Agency (ESA). Fitted into the Space Shuttle Orbiter's cargo bay, on Shuttle flight STS-9, Spacelab 1 was launched in November on a joint NASA/ESA mission; the science crew conducted a wide range of scientific and materials processing experiments during the 10-day flight, the longest Shuttle flight to date.

STS-9 was the last of four successful Shuttle missions flown during the year by the Orbiters *Columbia* and *Challenger*. The first, STS-6 in April, marked the flight debut of *Challenger* and included the first Shuttle extravehicular activity. On STS-7, a six-day mission in June, NASA launched two commercial communications satellites, Canada's Anik-2 and the Indonesian Palapa B-1, both built by Hughes Aircraft and both boosted to geosynchronous orbit by the McDonnell Douglas PAM (Payload Assist Module) upper stage propulsion system. On August 30, NASA launched STS-8 on a seven-day mission that included the first night launch and landing of the Shuttle, delivery of the Ford Aerospace/India INSAT-1B communications satellite, the first Shuttle-to-ground communications via the new TRW-built Tracking and Data Relay Satellite, and a variety of scientific experiments.

In addition to the four Shuttle missions, NASA used the McDonnell Douglas Delta, General Dynamics Atlas-F and Atlas Centaur and LTV Aerospace Scout expendable launch vehicles on 11 other 1983 satellite deliveries. All were successful; it was the seventh perfect launch record in NASA's 25-year history.

Aside from the Shuttle flights, the year's highlight was the January launch of the Infrared Astronomical Satellite (IRAS), a joint venture of the U.S., the United Kingdom and The Netherlands. IRAS proved to be one of the most successful scientific satellites of all time. In its short 10-month lifetime, limited by the supply of helium refrigerant needed to cool the telescope system, IRAS discovered a possible second solar system, five new comets, what might be a 10th planet in our solar system, and located some 200,000 objects detectable in infrared but not visible to ground-based telescopes.

In non-launch NASA activity, Martin Marietta Aerospace delivered the first two Manned Maneuvering Units (MMU), one-man spacecraft that allow astronauts to maneuver in orbit some distance from the Shuttle Orbiter without tether lines. The MMUs were to be checked out on Shuttle flight 41-B in February and used in the first retrieval operation on flight 41-C in April, when NASA astronauts will capture and repair the malfunctioning Solar Maximum Mission spacecraft.

The Pioneer 10 interplanetary probe, now 12 years out of home port Earth, became the first man-made object to depart the solar system on June 13. Pioneer 10 and its companion Pioneer 11, which is also bound for intergalactic space, were built by TRW Inc. In other interplanetary exploration, NASA's Voyager 2 continued on a trajectory that will take it to encounters with Uranus in 1986 and Neptune in 1989.

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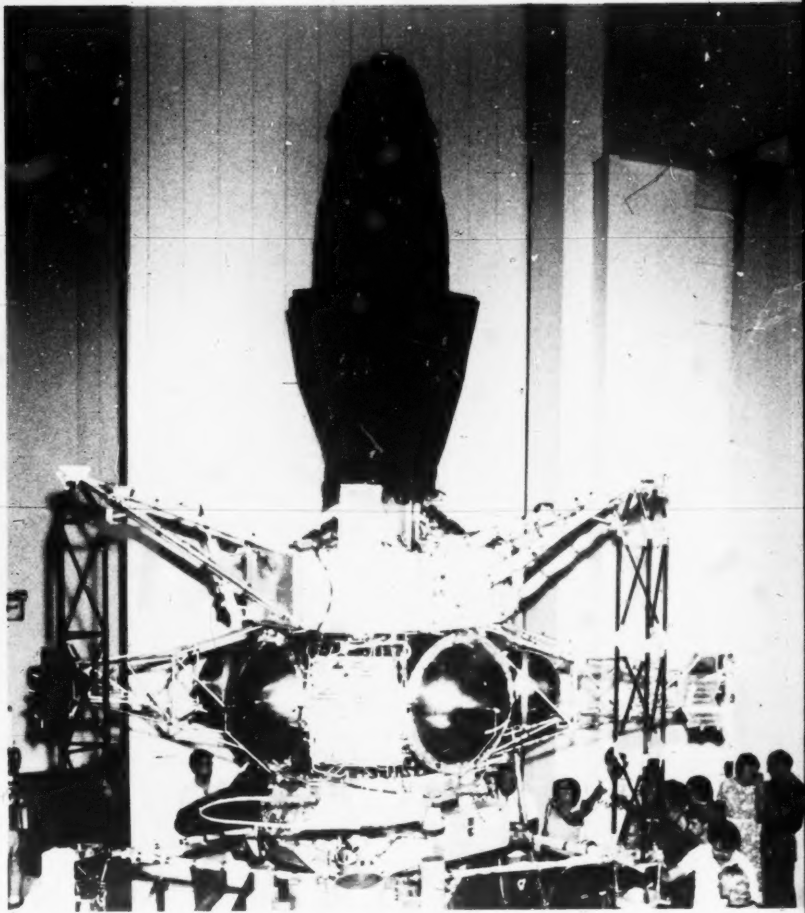

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1. Payload Specialist Byron Lichtenberg is conducting a materials processing experiment in the Spacelab orbital laboratory, which made its Shuttle debut in November.
2. Shown in pre-launch checkout is the Infrared Astronomical Satellite, which produced a wealth of important scientifc data during 10 months of operation.
3. NASA took delivery of the first two Manned Maneuvering Units, to be used for extravehicular activity by Shuttle-based astronauts.
4. In development for 1986 launch was the Galileo spacecraft, which will orbit Jupiter for 20 months and send an instrumented probe into the planet's atmosphere.

NASA's Space Station Task Force continued its planning effort, started in 1982, toward a permanent manned space station in low Earth orbit, to be operational in the early 1990s. Eight industry contractors were conducting studies of various aspects of the station; their preliminary recommendations for the initial station included a central base consisting of a cluster of modules, with living quarters for six to eight astronauts, a berthing and assembly module, a logistics module, a resources module and a laboratory module. They also recommended development of an Orbiting Maneuvering Vehicle, a robotic system to be used in conjunction with the manned base, and two Shuttle-serviced large unmanned platforms operating in low Earth orbit. Study contractors include Rockwell International, Grumman, General Dynamics, Boeing Aerospace, McDonnell Douglas Astronautics, Martin Marietta Aerospace, Lockheed Missiles & Space Company and TRW Inc. NASA's plan called for continuing studies in 1984, leading to program definition and start of hardware development in 1985/86, assuming Congressional authorization this year.

Among other major NASA development programs were:

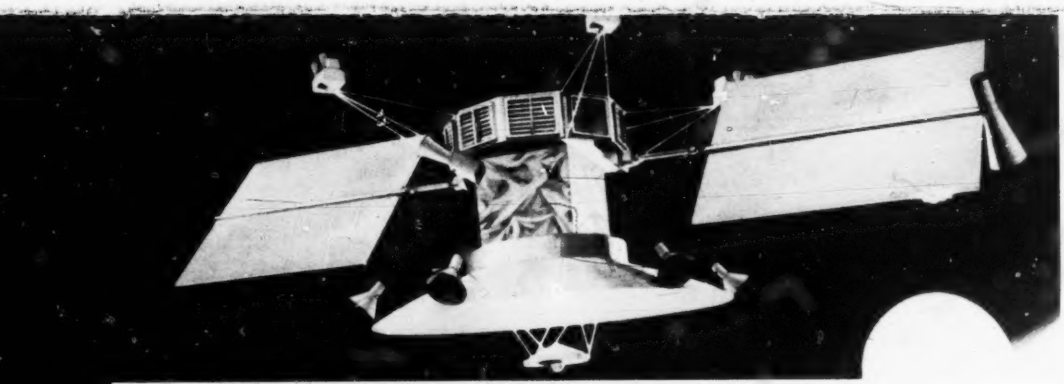
- Galileo, a two-spacecraft system—one an orbiter, the other a planetary probe—for advanced exploration of Jupiter. Jet Propulsion Laboratory (JPL) is building the orbiter; Hughes Aircraft and General Electric are teaming on probe development. Galileo is to be Shuttle-launched in 1986.
- The Venus Radar Mapper, a new start in 1983, a system for mapping the planet Venus with better clarity of detail than was possible with the earlier Pioneer Venus. To be launched in 1988, the VRM is being developed under JPL management by Martin Marietta Aerospace (spacecraft) and Hughes Aircraft (synthetic aperture radar).
- The Space Telescope, renamed the Hubble Space Telescope for a pioneer American astronomer, an orbiting observatory capable of peering to the edge of the universe and expanding man's view of the cosmos 350 times. Lockheed Missiles & Space Company is prime contractor for the spacecraft, Perkin-Elmer Corporation for the optical assembly. The observatory will be Shuttle-launched in 1986.
- The Solar Optical Telescope, an advanced astronomy system designed to op-

erate from the Shuttle Orbiter's cargo bay, thus allowing reusability; it will begin operations about 1990. Contractors are Lockheed Missiles & Space and Perkin-Elmer.

- The Advanced Communications Technology Satellite, a cooperative program with industry, designed to ease orbital communications congestion by means of new technology for more efficient use of the radio spectrum. NASA plans launch of a demonstration satellite in the late 1980s.
- The Gamma Ray Observatory, planned for launch in 1988 to study how gamma rays are produced and where they come from.
- The Advanced X-ray Astrophysics Facility, which will have instruments with about 100 times the sensitivity of prior x-ray spacecraft to provide information on the forces involved in the creation of stars, galaxies, quasars and black holes.
- The Upper Atmosphere Research Satellite, intended for late eighties launch for observations of the upper atmosphere's chemical composition and for studies of how human activities affect the atmosphere.

The military space program continued the rapid growth evidenced in recent years. Although details are classified, the Department of Defense generally is replacing existing communications, weather and intelligence-gathering satellites with more advanced systems, preparing for the 1985 introduction of the Space Shuttle for military operations, and developing advanced capabilities in space weaponry, missile attack warning, communications security and spacecraft survivability. Among unclassified developments of 1983,

- The USAF selected Lockheed Missiles & Space Company as prime contractor for development of Milstar, a highly survivable communications satellite that will operate in the extremely high frequency range. Targeted for service use late in this decade, Milstar will provide communications to Army, Navy, Marine Corps and Air Force strategic and tactical forces.
- The Department of Defense initiated operations with the advanced Defense Satellite Communications System Phase III (DSCS III) satellites built by General Electric. The satellite system will provide the military services non-jammable wideband communications.
- The USAF launched the eighth of 11 orbital test satellites of the Navstar Global Positioning System for precise location of air, sea and ground vehicles. Rockwell International was awarded a contract for production of advanced operational versions. Target for operation of the complete 18-satellite system is 1988. The potential of the system for civil use was demonstrated in June, when a civil airplane crossed the Atlantic from Cedar Rapids, Iowa to Paris navigating by means of the Navstar interim network.



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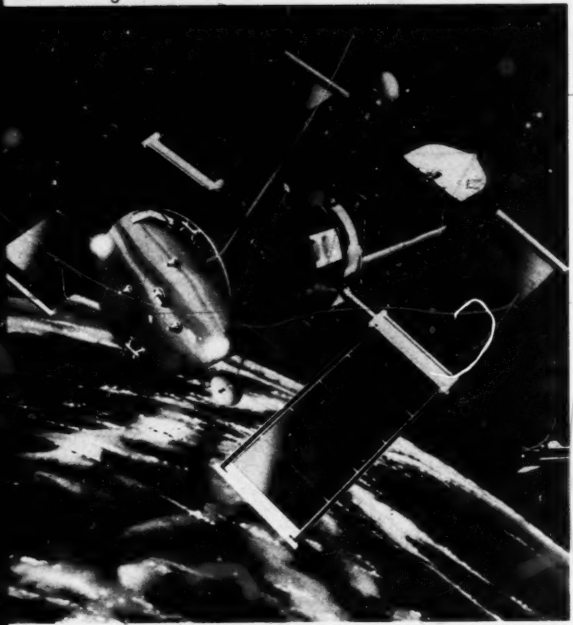

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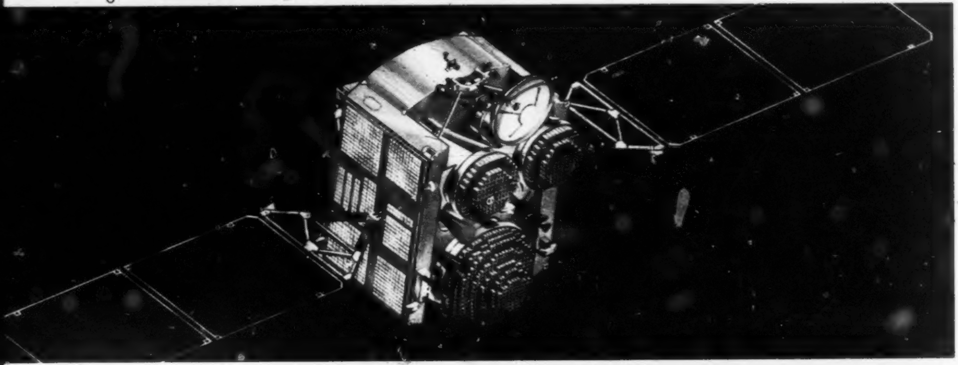
5. NASA began development of the Venus Radar Mapper for service beginning in 1988; its advanced imaging radar will penetrate Venus' cloud cover to map, in greater detail than earlier accomplished, 90 percent of the planet's surface.
6. Capable of looking seven times farther into the universe than the largest Earth telescopes, NASA's Hubble Space Telescope was in development for launch in 1986.
7. The Department of Defense initiated operations with the advanced, non-jammable Defense Satellite Communications System III.
8. The USAF launched the eighth of 11 orbital test satellites of the Navstar Global Positioning System; an 18-satellite operational system was targeted for service use beginning in 1988.



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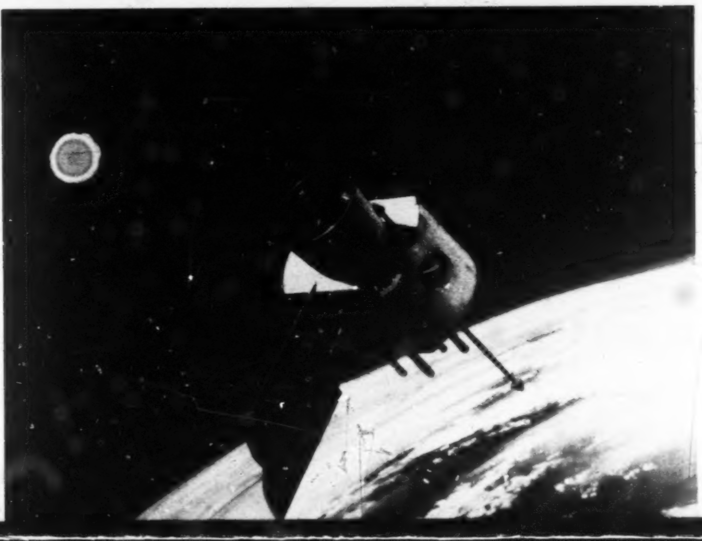

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CIVIL AVIATION

1. In January, Eastern Airlines introduced the Boeing 757 to commercial service.

2. In production during 1983 was the McDonnell Douglas MD-80 twinjet.

Near record volumes of passenger/cargo traffic and the first operating profit in four years marked the performance of the U.S. scheduled airlines in 1983. Preliminary figures indicated that the airlines carried 310 million passengers, up almost six percent over the previous year's 293 million. Air freight was estimated at 5.9 billion ton miles, up more than nine percent.

As a result of the improving economy, lower fuel prices and some increase in yield per passenger miles, the Air Transport Association (ATA) estimated a 1983 operating profit between $300 and $400 million, an encouraging signpost after operating losses of $733 million in 1982, $455 million in 1981 and $222 million in 1980. However, heavy interest burdens more than offset the operating profit and produced a net loss estimated between $200 and $400 million.

ATA predicted that passenger and freight volumes would set new records in 1984 and that operating profit might top $1 billion—but, due to continuing interest burdens, net income would range from breakeven to another loss. "The improvement in airline financial performance has begun," ATA said, "and it is expected to continue in 1984, but there is still a long, hard way to climb." Continued progress in the financial turnaround is essential for the acquisition of improved replacement aircraft, ATA added. About $4.6 billion worth of such equipment was delivered to U.S. airlines in 1983 and the airlines have on order for 1984 delivery another $3.1 billion worth.

On a worldwide basis, U.S. aircraft manufacturers recorded commercial transport sales of $7.9 billion, up sharply over 1982 but well below the levels of the three preceding years. At the end of September 1983, the transport backlog was $13.2 billion, down from $16.3 billion a year earlier; aircraft on order totaled 366, down from 455. Of particular note was the decline in orders from foreign airlines, down from $7.3 billion backlog in 1982 to $5.3 billion in 1983. As a percentage of total transport backlog, foreign orders have declined from 56.1 percent in 1980 to 35.5 percent at the end of September 1983.

In the commercial transport manufacturing segment of the aerospace industry, a highlight of the year was the January 1 service introduction of the Boeing 757 twin-engine, short-to-medium range jetliner. At the end of September, Boeing had orders for 63 757s. Also in production was the Boeing 767 advanced twinjet, in-

md-80
md-80
McDONNELL DOUGLAS

3

troduced to service in 1982; orders as of September totaled 88. In February, Boeing announced plans to develop a new 767-300, a stretched 254-seat derivative of the 767-200 in production. McDonnell Douglas was producing the renamed MD-80 (formerly DC-9 Super 80) with September orders on the books for 85 airplanes. The company was considering development of improved versions of the MD-80 for later production.

The rotary wing segment of the industry produced 415 helicopters valued at $278 million, down from the previous year's production of 587 units worth $365 million. Major commercial helicopter types in production included the Sikorsky S-76 and Bell Helicopter Textron Model 222 twin-turbine transports, and the Boeing Vertol 44-passenger Model 234. Bell started development of the Model 400 TwinRanger, a seven-seater with a four-blade main rotor made of composite materials; first deliveries were planned for 1985. Bell also introduced to service with hospitals the Med/Air 222UT medical transport.

In civil aircraft research, NASA continued advanced flight testing of the XV-15 Tilt Rotor Research Aircraft built by Bell Helicopter Textron and the Sikorsky Rotor Systems Research Aircraft (RSRA). In a joint NASA/Navy/Defense Advanced Research Projects Agency program, one of the RSRAs was being converted to X-wing configuration for flight testing; the X-wing features a rotor that can be stopped in flight to become, in effect, a fixed airfoil for greater cruise speeds than can be attained with a rotor system.

The NASA/Boeing Quiet Short-haul Research Aircraft, designed to demonstrate propulsive lift technology that could enable future short-haul transports to operate from very short runways, continued in flight test and topped the 500-hour mark in test time. NASA was considering a proposal by Ames Research Center for a follow-on high-speed propulsive lift research airplane, a modification of a Navy/McDonnell Douglas A-3B carrier-based attack aircraft. NASA's Advanced Turboprop Program progressed as Hamilton Standard division of United Technologies reached construction status on a nine-foot diameter swept-tip propeller system. NASA is-

4

sued a request for proposals for an aircraft modification, including engine and gearbox, to accommodate the nine-foot propeller assembly for flight testing to begin in 1987.

In 1983, the Federal Aviation Administration (FAA) brought the air traffic control system virtually to normal. Nearly all strike-related constraints were removed, traffic capacity rose and the number of active ATC personnel closely approximated staffing standards at year-end. Of the original 22 "pacing" airports—upon which FAA had imposed hourly traffic restrictions—only four remained at the end of the year. With the exception of Los Angeles International, host airport for the 1984 Olympics, all airports were to be dropped from the list of pacing airports by summer 1984. Flight restrictions within all 20 Air Route Traffic Control Centers were also lifted. The use of staff and supervisory personnel for controlling traffic was at a minimum at year-end and was expected to be discontinued by July 1984.

FAA was also laying the foundation for a more sophisticated future system in accordance with the National Airspace (NAS) Plan. Highlights included:

- Approval by the Secretary of Transportation, in April, for procurement of all 1,250 Microwave Landing Systems called for in the NAS plan. FAA issued a request for proposals for the first 172 units, to be delivered over a five-year period.
- Award of two contracts, in September, for competitive design of advanced, higher capacity ATC computers to replace those now in use at Air Route Traffic Control Centers.
- Issuance of a request for proposals, in May, for the Advanced Automation System, a key element in the NAS Plan for upgrading and modernizing the ATC and air navigation systems.
- Award of a contract for a new generation airport surveillance radar, the ASR-9, to be installed at 137 airports. The ASR-9 features separate channels to provide information on aircraft and weather. It will generate weather data indicating six different levels of intensity, ranging from weak to extreme. Using this information, a controller will be able to guide pilots away from areas of severe weather.

5

HELIKOPTER SERVICE

6

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3. Sikorsky Aircraft continued production of the S-76 twin-turbine transport.
4. Bell Helicopter Textron introduced to service with several hospitals the Model 222UT Med/Air medical transport.
5. Bell started development of the Model 400 TwinRanger and began flight tests of a pre-production prototype.
6. Boeing Vertol made additional deliveries of its 44-passenger Model 234, this one to Norway's Helikopter Service.
7. The system pictured is a model of Hamilton Standard's nine-foot diameter swept-tip propeller assembly, being built for 1987 flight test under NASA's Advanced Turboprop Program.

AEROSPACE REVIEW

In 1983, aerospace industry sales increased some four percent in inflation-adjusted terms, rebounding from the previous year's decline to the highest level in 14 years. Both export sales and international trade balance increased after a dip in the previous year; backlog and profits gained, and employment increased slightly.

Here is a summary of the aerospace year 1983 based on preliminary data:

Sales. Total industry sales amounted to $74.7 billion, up from $67 billion in 1982. In current dollars, the 1983 sales volume was the highest in the industry's history; in real, inflation-adjusted terms, it remained below the peak years 1967-69. The industry recorded 1983 real increases in the military aircraft, missiles and space categories that more than offset declines in civil aircraft and non-aerospace products.

Sales of military aircraft increased from $24.4 billion in 1982 to $27.7 billion in 1983. Space sales, civil and military combined, rose sharply to $14.3 billion, compared with $11 billion in the previous year. Missile activity, at $9.3 billion, was up some $900 million. Civil aircraft sales totaled $12 billion, up slightly in current dollars but down 4.7 percent in real terms. Sales of non-aerospace products, $11.4 billion, fell just below the 1982 level.

Backlog. Orders on the industry's books at year-end 1983 totaled $115.5 billion, up $11.9 billion over 1982. Orders from the U.S. government—$71.9 billion—accounted for 62 percent of the total.

International Trade. The aerospace export volume of $16.3 billion included civil sales of $10.6 billion and military exports amounting to $5.7 billion. The total figure was higher than the 1982 level of $15.6 billion but it remained below the peak of $17.6 billion recorded in 1981. Aerospace imports declined almost 25 percent to $3.5 billion. The aerospace balance of trade—$12.8 billion—represented an increase of 16.3 percent.

Earnings. The industry's 3.6 percent profit-to-sales rate remained below the average—3.8 percent—for all U.S. manufacturing corporations. The 1983 aerospace profit rate compares with an average of 4.3 percent for the five preceding years. The major factor in the gradual decline of the profit rate is the higher ratio of military sales to commercial sales; historically, military sales yield lower profit.

Plant and equipment. Aerospace industry expenditures for new plant and equipment fell by $1.2 billion to $4.9 billion; as a percentage of sales, they declined from nine percent in 1982 to 6.5 percent in 1983. However, a substantial increase is indicated for 1984, up almost $1 billion to $5.8 billion, 7.1 percent of sales.

Employment. Aerospace employment increased slightly; the industry work force at year-end totaled 1,171,000, up from 1,153,000 at the end of 1982.

AND FORECAST 1983/1984

FORECAST

Aerospace Industries Association projects a real sales increase of three percent for 1984, due largely to anticipated increases in military research, development and production activities. Overall industry sales in 1984 are estimated at $82.3 billion. Employment is expected to rise by more than 50,000 to 1,223,000.

Defense. AIA estimates that sales of aerospace products to the Department of Defense will top $45 billion in 1984. That represents an increase of about 20 percent over 1983, with gains expected in all categories—aircraft, engines and parts, missiles and space. For the long term, the view is necessarily cloudy due to national debate as to the level of defense expenditures. On the basis of backlog, the industry anticipates increasing levels of defense sales over the next two or three years. Beyond that, if Congress generally supports the Administration's defense expansion plan—even with some funding reductions—high levels of aerospace industry defense activity are expected into the 1990s.

Space. In 1983, sales of space-related equipment led all industry gains with an increase of 30.5 percent; as a percentage of total sales, the space product group became the second largest among industry workload categories, trailing only military aircraft production. The major reason was the significant growth in defense outlays for space systems, a trend in evidence for several years and one expected to continue if the nation follows through on the defense buildup plan.

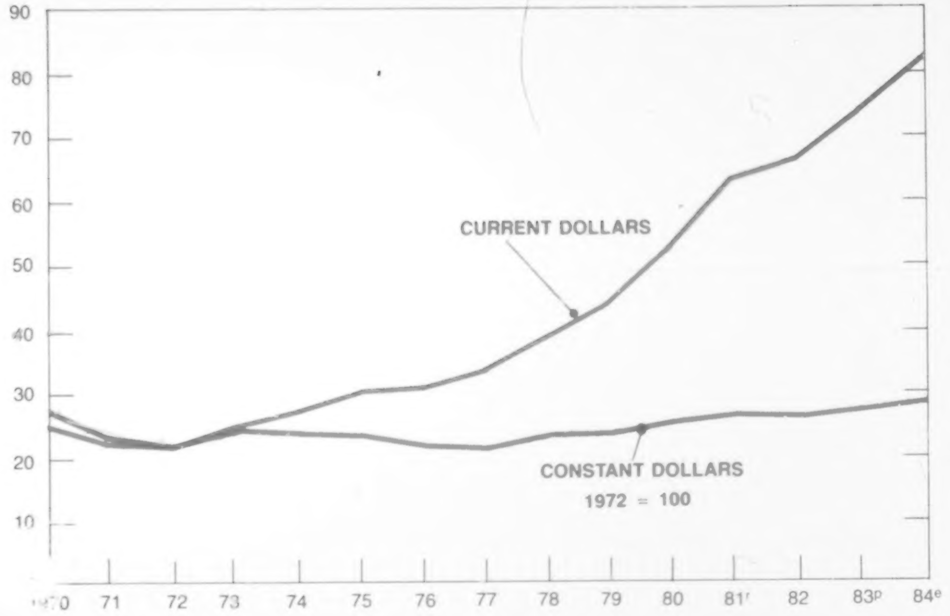
NASA sales were also up in 1983 and moderate gains are anticipated in that area. In addition, prospects are bright in the third area of industry space activity—commercial sales. Projections indicate large-scale growth in industry fabrication of commercial space systems, principally communications satellites but also including such new areas of space commercialization as launch vehicles, upper stage boosters and free-flying platforms for commercial experimentation. Thus, with gains indicated in all three areas—military, NASA, commercial—the industry's space workload bids to become an even more significant proportion of total sales in the 1980s and beyond. For 1984, AIA estimates total space sales at $16.3 billion, up 14 percent.

Civil Aircraft. Total 1984 sales of civil aircraft products are expected to drop 10.7 percent, from $12 billion in 1983 to $10.7 billion. Increases are expected in deliveries of helicopters and general aviation aircraft, due to the improving economic situation of many corporate customers. However, shipments of commercial transport aircraft will decline from $7.9 billion in 1983 to $6.2 billion.

For the longer term, improvements in airline industry operating profits are encouraging signposts. If the airlines' financial health permits early resumption of transport orders on the scale projected—$150 to $250 billion over the years 1984-95—the aircraft manufacturing segment of the industry should experience very high levels of jetliner production during the 10-year span beginning in 1986.

AEROSPACE INDUSTRY SALES

(Billions of Dollars)

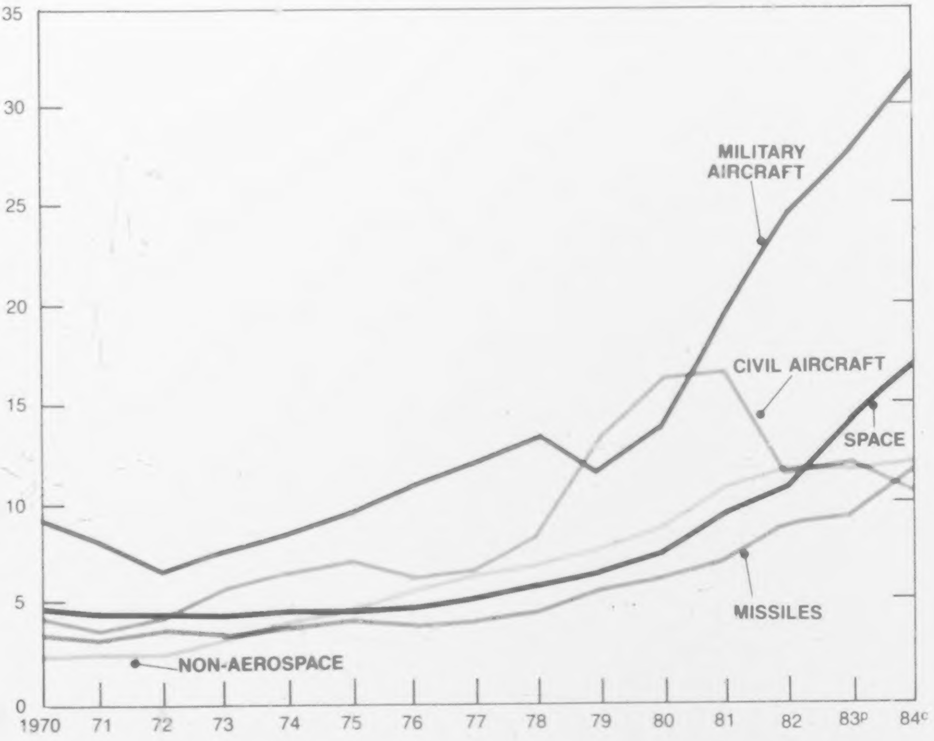


Source: Aerospace Industries Association
r Revised
p Preliminary
e Estimate

The aerospace industry's 1983 total sales of $74.7 billion included $63.3 billion in sales of aerospace products and services, plus $11.4 billion in non-aerospace sales. The Department of Defense predominates in a breakdown of aerospace sales by customer; DoD sales amounted to $37.9 billion, while sales to NASA and other government agencies totaled $6.1 billion. Non-government sales of aerospace products and services were $19.3 billion, an increase over the previous year's level but a figure well below the 1981 peak of $21.1 billion. For 1984, Aerospace Industries Association projects sales of $82.3 billion, with about $70 billion of the total in aerospace sales.

AEROSPACE INDUSTRY SALES BY PRODUCT GROUP

(Billions of Current Dollars)

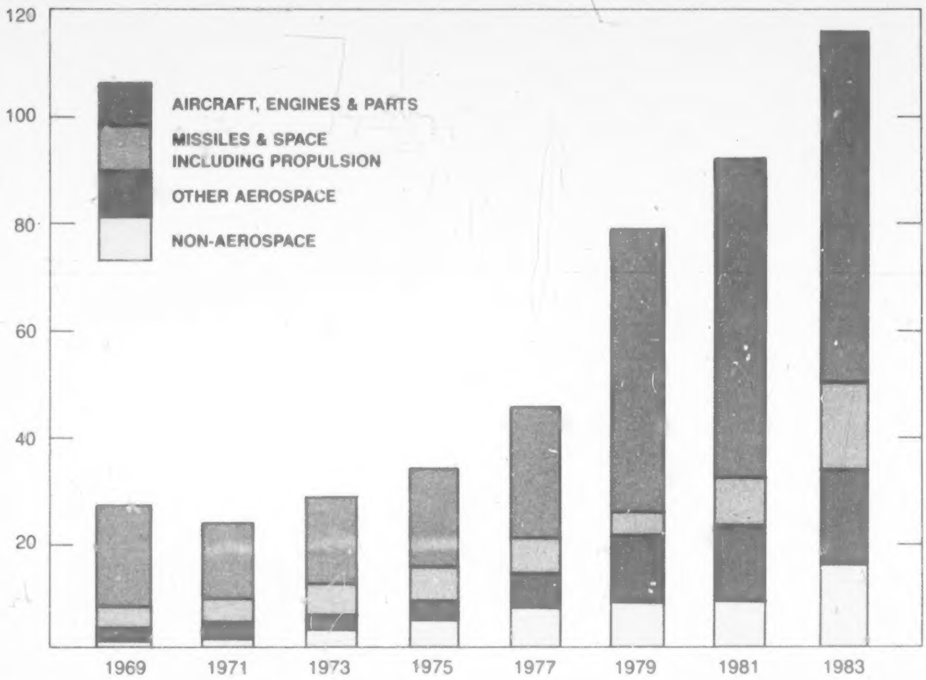


Source: Aerospace Industries Association
p Preliminary
e Estimate

As is customary, aircraft production represented the largest single element of the 1983 sales volume—more than 53 percent. Sales of military aircraft topped civil aircraft sales by a wide margin, increasing 13.5 percent; sales of civil aircraft increased 2.3 percent. The largest gain—30.5 percent—was in space-related equipment, a category that moved into second place among industry product groups. In 1984, military aircraft sales are expected to increase by 13.6 percent while civil aircraft sales will drop 10.7 percent. Space products will remain in second place with a gain of 13.6 percent.

AEROSPACE INDUSTRY BACKLOG BY PRODUCT GROUP

(December 31, selected years, billions of current dollars)

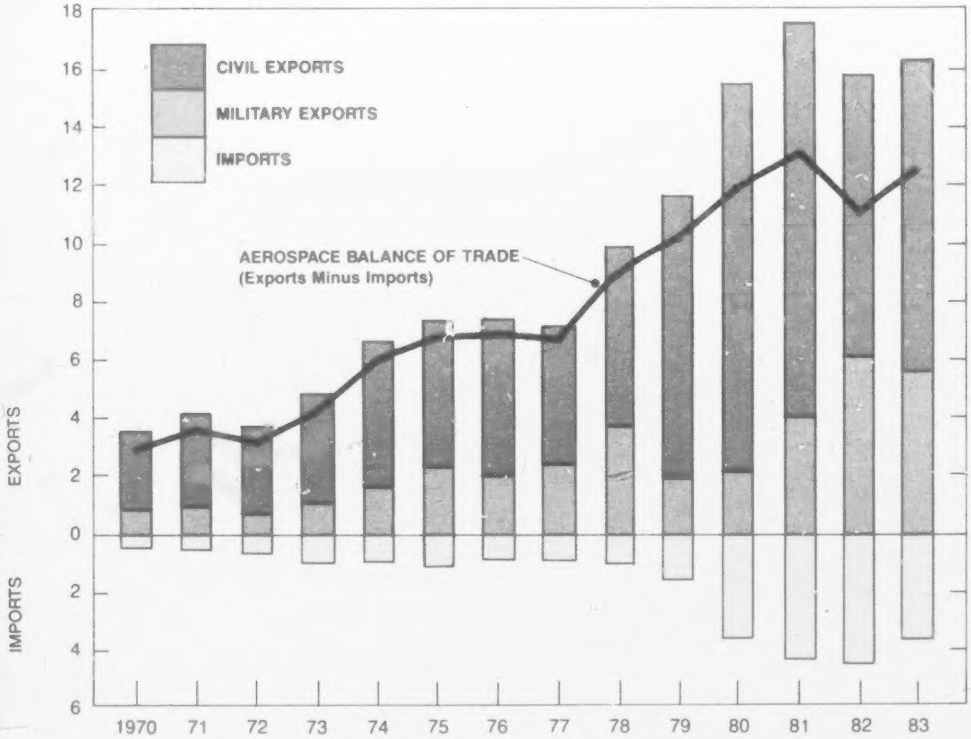


Source: Aerospace Industries Association, based on date from the U.S. Department of Commerce, Bureau of the Census and AIA estimates.

The aerospace industry's backlog of orders at year-end 1983 was $115.5 billion, up 11.5 percent over the $103.6 billion on the books at the end of the previous year. Orders from the U.S. government—$71.9 billion—accounted for 62 percent of the total. Orders for aircraft, engines and parts constituted more than 56 percent. A breakdown of other backlog shows more than 13 percent in orders for missile and space systems, more than 16 percent in "other aerospace" products, and about 15 percent in non-aerospace products.

AEROSPACE EXPORTS, IMPORTS AND TRADE BALANCE

(Billions of Current Dollars)



Source: Bureau of the Census.

The 1983 aerospace export volume increased to $16.3 billion from 1982's $15.6 billion; civil exports, including aircraft, engines and parts, amounted to $10.6 billion and military exports totaled $5.7 billion. The 10.3 percent increase in civil exports was driven by gains in shipments of transport aircraft and turbine engines. Military exports, principally transports, helicopters and missiles, declined by 5.2 percent.

Aerospace imports, at $3.5 billion, fell 24.5 percent below the $4.6 billion peak recorded in the previous year. The $12.8 billion balance of trade was up 16.3 percent over 1982's $11 billion, but it remained below the 1981 all-time high of $13.1 billion.

CIVIL AIRCRAFT SHIPMENTS

(Calendar Years 1968–1984)

	NUMBER OF AIRCRAFT SHIPPED				VALUE (Millions of Dollars)			
Year	TOTAL	Commercial Transport Aircraft[a]	Helicopters	General Aviation	TOTAL	Commercial Transport Aircraft[a]	Helicopters	General Aviation
1968	14,922	702	522	13,698	$ 4,267	$3,789	$ 57	$ 421
1969	13,505	514	534	12,457	3,598	2,939	75	584
1970	8,076	311	482	7,283	3,546	3,158	49	339
1971	8,158	223	469	7,466	2,984	2,594	69	321
1972	10,576	227	575	9,774	3,308	2,660	90	558
1973	14,709	294	770	13,645	4,665	3,718	121	826
1974	15,326	332	828	14,166	5,091	3,993	189	909
1975	15,251	315	864	14,072	5,086	3,779	274	1,033
1976	16,429	222	757	15,450	4,592	3,078	285	1,229
1977	17,913	155	848	16,910	4,451	2,949	251	1,551
1978	18,962	241	904	17,817	6,458	4,308	328	1,822
1979	18,450	376	1,019	17,055	10,644	8,030	403	2,211
1980	13,634	387	1,366	11,881	13,058	9,895	656	2,507
1981	10,916	387	1,072	9,457	13,223	9,706	597	2,920
1982	5,085	232	587	4,266	8,610	6,246	365	1,999
1983(p)	3,363	263[b]	415	2,685	9,632	7,919[b]	278	1,435
1984(e)	4,392	188[b]	554	3,650	8,591	6,167[b]	424	2,000

Source: Aerospace Industries Association, based on company reports, data from the General Aviation Manufacturers Association, and AIA estimates.

[a] Includes all U.S. manufactured civil jet transport aircraft plus the turboprop-powered Lockheed L-100.

[b] Includes MD-80 transport aircraft shipped under lease agreements.

(p) Preliminary.

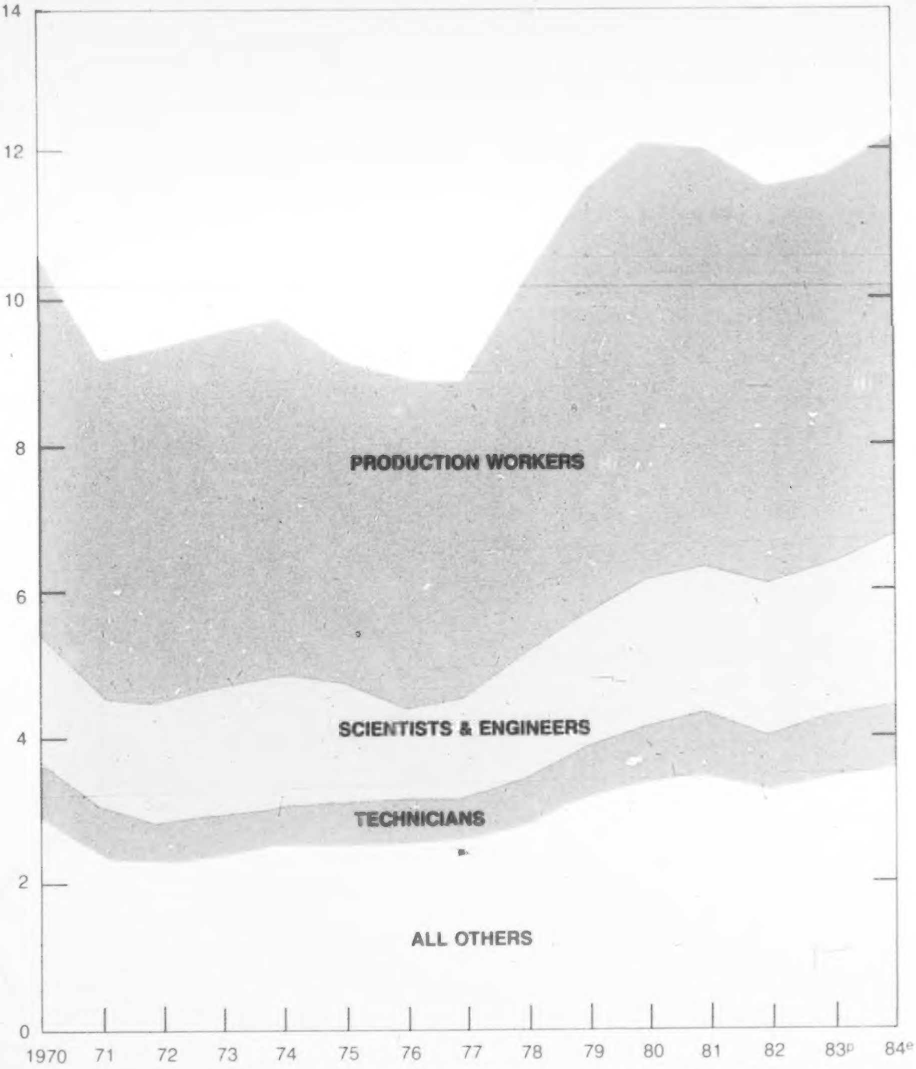
(e) Estimate.

Shipments of civil aircraft continued to decline in numbers but dollar value of shipments increased over 1982. The industry delivered 3,363 aircraft, down more than 1,700 units from the 1982 level and only 18 percent of the peak year (1978) total shipments. Total dollar value—$9.6 billion—was up almost $1 billion over the previous year, reflecting an increase in higher-value transport aircraft deliveries that more than offset drops in helicopter and general aviation shipments. The $9.6 billion figure is the value of complete aircraft delivered during the year; it differs from the earlier-mentioned civil sales figure of $12 billion in that the latter number includes the value of spare engines and parts.

Commercial transports accounted for some 82 percent of the total dollar value of civil aircraft deliveries. The industry delivered 263 transports (up from 232 in 1982) worth $7.9 billion (up from $6.2 billion). General aviation shipments fell to 2,685 (down from 4,266) valued at $1.4 billion (down from $2 billion). Helicopter deliveries dipped to 415 units (down from 587); dollar value was $278 million, compared with $365 million in the previous year. Projections for 1984 show total shipments of 4,392 aircraft valued at $8.6 billion, an increase in numbers but a decline in dollar value due to an anticipated reduction in commercial transport deliveries.

AEROSPACE EMPLOYMENT

(hundreds of thousands of employees as of December 1968–84)



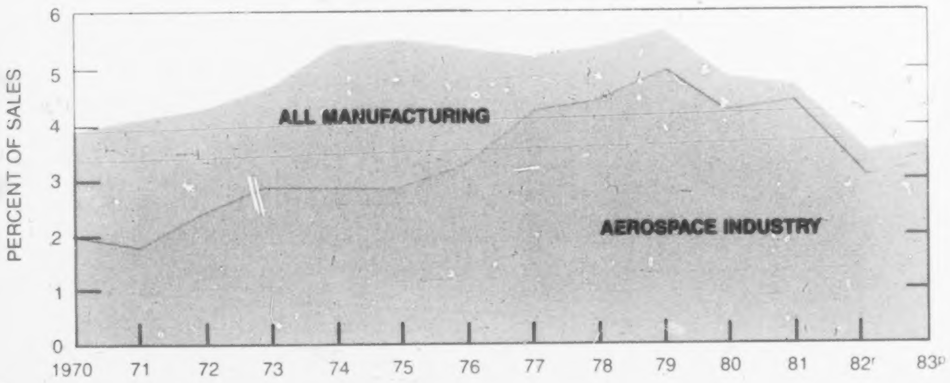
Source: Aerospace Industries Association, based on data from the U.S. Department of Labor, Bureau of Labor Statistics, "Employment and Earnings," and AIA Semi-Annual Survey of Aerospace Industry of Employment.

p Preliminary

e Estimate

At year-end 1983, the aerospace industry labor force numbered 1,171,000, up from 1,153,000 at the end of the previous year. The largest increase was in production workers (up 8,000 to 543,000). The number of scientists and engineers increased by 6,000 to 206,000, and technicians increased by 2,000 to 81,000. There was also an increase of 2,000 in the "all others" category. For 1984, AIA projects an employment gain of 52,000 to a year-end total of 1,223,000. The aerospace payroll for 1983 reached a new high of $35 billion and estimates for 1984 indicate a further rise to $38.3 billion.

NET PROFIT AFTER TAXES



Source: Aerospace Industries Association

r Revised

p Preliminary

The aerospace industry recorded a profit after taxes of $3 billion in 1983, up from $2.2 billion in 1982. Measured as a percentage of sales, the profit rate was 3.6 percent in 1983; that compares with 3.3 percent in 1982 and an average of 4.3 percent for the five year period 1978–82. The 1983 figure compares with a profit rate of 3.8 percent for all U.S. manufacturing industries.

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St. N.W. Washington, D.C. 20036

AIA

MEMBERS

- Abex Corporation
- Aerojet-General Corporation
- Aeronca, Inc.
- Allied Corporation/Bendix Aerospace
- Allison Gas Turbine Operations
  - General Motors Corporation
- Aluminum Company of America
- Avco Corporation
- The Boeing Company
- Colt Industries Inc.
  - Chandler Evans Inc.
  - Menasco Inc.
- Criton Corporation
- E-Systems, Inc.
- FMC Corporation
  - Ordnance Division
- The Garrett Corporation
- Gates Learjet Corporation
- General Dynamics Corporation
- General Electric Company
- The BF Goodrich Company
- Goodyear Aerospace Corporation
- Grumman Corporation
- Hercules Incorporated
- Honeywell Inc.
- Hughes Aircraft Company
- IBM Corporation
  - Federal Systems Division
- ITT Defense Space Group
  - ITT Aerospace/Optical Division
  - ITT Avionics Division
  - ITT Defense Communications Division
  - ITT Federal Electric Corporation
  - ITT Gilfillan
- Lear Siegler, Inc.
- Lockheed Corporation
- LTV Aerospace and Defense Company
- The Marquardt Company
- Martin Marietta Aerospace
- McDonnell Douglas Corporation
- Morton Thiokol, Inc.
- Northrop Corporation
- Parker Hannifin Corporation
- Pneumo Corporation
  - Cleveland Pneumatic Company
  - National Water Lift Company
- Raytheon Company
- RCA Corporation
- Rockwell International Corporation
- Rohr Industries, Inc.
- The Singer Company
- Sperry Corporation
- Sundstrand Corporation
- Teledyne CAE
- Textron Inc.
  - Bell Aerospace Textron
  - Bell Helicopter Textron
  - HR Textron Inc.
- TRW Inc.
- United Technologies Corporation
- Western Gear Corporation
- Westinghouse Electric Corporation
  - Energy & Advanced Technology Group
- Wyman-Gordon Company

aerospace

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READY OR NOT?

U.S. defense forces—
readier than ever

Notable views of notable people on aerospace matters...

Murray L. Weidenbaum, *Director of the Center for the Study of American Business, Washington University, St. Louis, Missouri, writing in the Christian Science Monitor:*

"The existing detailed bureaucratic oversight of military production is counterproductive. It has not prevented numerous cost overruns and problems with quality control. The record of competition in the private marketplace, in contrast, has been impressive over the years—driving down costs and providing efficient production. Thus, substituting economic incentives for detailed surveillance of the operations of government contractors is likely to produce more defense output for the dollar . . .

"The key to making defense contracting more efficient is an increased reliance on private enterprise. Actually, we have not given it much of a chance. Defense contracts are awarded to private companies, but the contracts require the companies to behave like arsenals. Rather than concentrating on performance, contractors spend their time studying the government's rule books. Thus, the nation does not get the full benefit of the innovation and efficiency that we expect from the private sector."

Norman R. Augustine, *President, American Institute of Aeronautics and Astronautics, in an Aerospace America editorial:*

"Must aerospace follow the flight path of steel and autos? Clearly not . . .

"What is to be done? The first task is to increase public awareness of the importance to the nation of maintaining a healthy industrial base, particularly in hi-tech products . . .

"The second task to be addressed relates not to what should be done but what should *not* be done. We should not, for example, adopt trade barriers as a counter to predatory trade practices engaged in by some foreign nations. Protectionism is a part of the problem, not a part of the solution.

"The task at hand should be one of supporting a *positive* policy based on competitive strength through superior R&D and through enhanced productivity backed by government sanctions selectively targeted against foreign and domestic violations of free trade practices.

"The ingredients of such a policy should include, but not be limited to, *major* tax incentives for R&D expenditures, expanded tax credits for work performed under industry contracts to universities, and tax incentives for productivity investments. Further, in recognition of the fact that risks inherent in many major aerospace R&D programs often exceed the capacity of individual firms to endure, antitrust laws should be liberalized to permit greater latitude in pursuing cooperative projects—so long as the direct threat of a monopoly is not present. Finally, to assure that no nation reaps advantage from predatory pricing, the U.S. Export-Import Bank should make clear that, as a deterrent, it will meet any and all foreign government-backed financing offers in our key export industries.

"Given these steps, the nation of the Wright Brothers and Henry Ford may yet dispel the economic storm clouds now gathering over the U.S. aerospace industry."

Michael Howard, *Regius Professor of Modern History at Oxford University and Britain's foremost military historian, in an interview published in U.S. News & World Report:*

"Wars don't just happen; people *make* war—and they do so when they think that this provides them with a better option than not making war. In the 'good old days' of conventional forces, it was not too difficult to visualize circumstances in which one might emerge from a war in better shape than one went in . . . With nuclear weapons, the whole balance of cost and benefit has been radically tilted . . . For most countries, any use of nuclear weapons against one's own territory would be a catastrophe beyond imagining, a man-made disaster far surpassing anything that has happened to mankind before . . .

"The prospect of this happening is a profound and unprecedented deterrent against making war. That is why I am not in favor of the total abolition of nuclear weapons.

"I think that the development of nuclear weapons has given us a chance for the indefinite future of preventing the outbreak of major war, at least between powers armed with nuclear forces. One can't say, of course, that it will never happen. But I think that the possibilities of major war are far more remote as a result of the existence of nuclear weapons than they ever were in the past."

Correction: In the preceding issue of *Aerospace*, Hughes Aircraft Company was erroneously identified as manufacturer of the Army AH-64 Apache antitank helicopter. The AH-64 is built by Hughes Helicopters, Inc., a wholly owned subsidiary of McDonnell Douglas Corporation. Hughes Helicopters, the industry AH-64 development team and the U.S. Army were co-winners of the Collier Trophy for "giving a new battlefield capability to the American soldier."

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CONTENTS

2 DEFENSE AND THE FREE ENTERPRISE SYSTEM
By General James P. Mullins, USAF

4 READY OR NOT?
By James J. Haggerty

7 Rx FOR EXPORT EXPANSION
By Karl G. Harr, Jr.

10 AEROSPACE TECHNOLOGY FOR THE 1990s
By C. Ronald Lowry

12 THE ADVANCING ART OF SIMULATION
By Laura Overstreet

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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CONTROLLING TECHNOLOGY TRANSFER

BY KARL G. HARR, JR.,
President, Aerospace Industries Association

The Soviet Union is increasingly taking advantage of Western technologies in its research and development programs. Most of this technology is acquired by espionage and other illegal means, but some of it reaches the U.S.S.R. through legal channels.

This is a matter of serious concern. Clearly, the U.S. must effect measures to curb the flow of technology to nations that might use that technology against us. The Departments of Defense and Commerce are jointly developing a system for controlling technology transfer, the key element of which is a list of technologies to be barred from export. The aerospace industry supports that effort—to the extent that such controls are practicable, enforceable and realistic. But in adopting control measures we must carefully consider their impact on U.S. trade expansion.

The currently declining U.S. international trade trend poses a serious threat to our nation's future, thus ranks with technology transfer as one of our most pressing national concerns. We must reverse the trend, particularly by focusing on high technology exports, our strength in international trade competition. But this goal conflicts to some degree with the goal of barring advanced technologies to our potential adversaries. Excessively broad imposition of controls could restrict American high technology exports without gaining any real security advantage—either because the controls are unenforceable or because we cannot unilaterally deny access to the technologies involved.

We must accept the reality that the U.S. is not the world's sole repository of advanced technology. We are familiar with the great strides in technical competence achieved by Japan and European nations; additionally, there are signs of increasing technological capacity among a number of other industrially-rising nations. Thus, controlling the export of American technology does not insure denying Eastern bloc access to comparable technology. Unilateral control by the U.S., without similar constraints on our competitors, will leave us at a disadvantage in the international marketplace yet do little or nothing to strengthen our national security.

The logical road to controlling technology transfer is the multilateral approach, working in concert with our friends and allies through the international organization known as the Coordinating Committee, or CoCom. The U.S. government should seek to make CoCom a more effective control instrument by strengthening its technology transfer enforcement mechanisms and by improving the consistency of rules interpretation by all members of that body.

The aerospace industry also feels that the current list of proscribed products and technologies, some 800 pages long, is far too broad and complex. An essential step in developing a foundation for agreement among CoCom partners is a sharp reduction in the scope of the list—limiting it to those technologies whose transfer to the Soviet Union and its Warsaw Pact allies would have particular military significance.

Most importantly, the technology transfer control system must achieve a balance between security considerations and trade restrictions. That will not be easy, given the complexity of the subject. However, the aerospace industry feels it is possible of attainment if the parties involved approach the matter in a spirit of cooperative compromise, recognizing that it is counterproductive if we single-mindedly pursue one major national goal at the expense of another.

DEFENSE AND THE FREE ENTERPRISE SYSTEM

By GENERAL JAMES P. MULLINS,
Commander,
Air Force Logistics Command

A command pilot with 38 years of service in the Air Force, General James P. Mullins is a veteran of the Korean and Vietnam wars; during the latter conflict, he flew 110 combat missions with a tactical reconnaissance wing. His post-Vietnam assignments included four years in the USAF Office of the Deputy Chief of Staff, Research and Development; five years in several posts within the Air Force Logistics Command; and three years as commander of the 15th Air Force. He assumed his present command in July 1981.

For some time I have been speaking out in support of America's free enterprise system of providing national defense and the special relationship between the armed forces and the private sector, that special relationship which has done so much for our nation and the free world. Frankly, I believe the military-defense industry complex needs more support and less criticism, especially considering that it has kept us free for over 200 years and has protected and defended much of the free world from those dark forces which have always threatened it.

The words "military industrial complex" are so laced with the pitfalls of unbridled emotionalism that most people, either in the military or private industry, will avoid using them at all cost. A degrading mythology has developed around our defense industry, a mythology that runs exactly counter to what it should be, given the reality of the situation. Because without the military and private industry working closely together in a free enterprise environment, much of the technological excellence we rely on for our survival simply would not exist.

In 1939, when the great threat of Axis tyranny grew relentlessly around us, Franklin Roosevelt recognized the tremendous advantage this nation had in its free enterprise system. He knew what could be achieved if only private industry were properly incentivized. That's why he dubbed American industry the "Arsenal of Democracy", and that's why he provided the necessary incentives. It was the millions of weapons and spare parts produced by industry during a 44-month period that allowed us to win World War II and prevent the enslavement of the free world. Indeed, without our defense industry, we would have lost that great conflict.

But perhaps we owe an even greater debt to our free enterprise system for its achievements during the postwar period, because that's when this country faced an even greater menace—one which, unlike that of World War II, could threaten America's heartland, towns and cities which, until then, had been invulnerable.

As modern military technology evolved and our potential adversaries, especially the Soviets, developed strategic systems against which there was no defense, we were faced with building a strong and unquestioned deterrent, one that could prevent an attack against our country and insure the survival of democracy. Considering the speed at which technology was evolving, and the continuing pressure of an ever-growing threat from the Soviet Union, that was truly an undertaking of immense proportions.

The postwar era was a really remarkable period for the military, our private defense industry, and this country, because it saw the foundation laid for what has proven to be the most effective deterrent ever known to man. It showed once again, to friend and foe alike, what American free enterprise is capable of doing—above all else, it has prevented another world war.

Considering all the good it has done and the contributions it has made, one must wonder why our defense industry suffers in so many quarters from such a poor image? Why is it so frequently maligned, often by the very people it has benefited the most? In general, of course, it shares in the ridicule most big business has been held up to in recent years—especially in the media. But, more specifically, it also suffers because the public does not have a good understanding of defense spending, particularly in terms of the size of military budgets, the impact of this spending on society in general, and the credibility gap created by celebrated cases of defense industry fraud or abuse.

I believe the defense industry has suffered an undeserved image because the substantial size of our defense industry, and the large numbers of dollars involved, attract a great deal of attention. There is certainly no doubt in anyone's mind these days that defense is big business in this country. But that doesn't mean defense spending is the wasteful and unproductive drain on our economy which many believe it to be.

It is important for Americans to understand that defense represents only 17 percent of our total public spending, which is down from a postwar high of 36 percent in 1955. In fact, today it represents only about six percent of our Gross National Product—less than half of what the Soviets now spend—and about 17 percent of what we spent during the height of World War II.

Americans also need to be aware that defense dollars are not just investments in defense. Money in the military budget is not poured into some dark abyss, never to be seen again. In fact, 41 percent of the 1983 defense budget went directly to paying salaries, to putting money into the pockets of over five million employees in our nation's defense program. And what they do with it, of course, is spend it in stores, and save it in banks, credit unions, or savings and loans. They use it to buy cars and homes, they use it to send their kids to school, they use it to pay their taxes, and they give it to charity. Indeed, a large part of every defense dollar directly supports hundreds of local communities, many in economically austere environments which otherwise would have limited sources of reliable financial support.

Military spending also provides this nation with another major benefit: it encourages technical innovation and stimulates scientific discovery. Military applications require a great deal of advanced research and development in fields ranging from aerodynamics to human factors. And because they serve to push the state of the art across the board, they generate many spinoff technologies, all of which, in one way or another, benefit the American public.

"The military-defense industry complex needs more support and less criticism. . . . We face a grave threat today . . . but that vital partnership of the military and private industry gives us the trump card we need, for it can generate the 'Yankee ingenuity' we have relied upon successfully for more than two centuries."

Clearly, taxpayers' dollars are not squandered when they are invested in the nation's defense. For our defense industry is not that dark abyss into which everything good is given, and from which nothing good is returned. But tragically and dangerously, there are many in this country who think it is. We must controvert that impression by putting the facts on the table where they can be legitimately and objectively evaluated.

In addition, we must insure that the taxpayers of this nation can be confident that they are receiving every ounce of national defense possible from every dollar spent. Frankly, we have not done very well in this regard lately—not with the parts pricing "horror stories" that have been circulating. Such reports can quickly undermine the credibility of our entire defense program—and further erode the image of our arsenal of democracy.

This alone represents a serious threat to our country's security, and the security of the free world, and we must do something about it right now. What that means is getting in sync with the basic laws of supply and demand; that means again taking advantage of the strengths of free enterprise; and that means incentivizing competition across the board. Because virtually all the defense acquisition problems we have encountered recently—the aging plants, disappearing contractors, vanishing skills, long lead-times, and high prices—came about as a result of our meddling with the free enterprise system, by our limiting competition or allowing it to wither away.

Fortunately, working closely with private industry, the Air Force has already come a long way in remedying this situation. We are now effectively using the system to provide more visibility to cost increase anomalies by giving our people the means to challenge any price which they believe is out of line and by establishing validated prices so that we can better judge what increases we do find. We are also improving the procurement procedures we use, and we are taking better advantage of new management technologies that have recently become available. We are already seeing substantial results.

So, let me reiterate that there is no reason why Americans should not be proud of their military industrial complex, because it has worked well in the past, and it can continue to work well in the future. However, we must press hard for an open, competitive environment, we must improve the way we do business and we must take better advantage of the inherent strengths of the free enterprise system.

We face a grave threat today, a threat to our free way of life and a threat to our very survival. But that vital partnership of the military and private industry gives us the trump card we need, for it can generate the "Yankee ingenuity" we have relied upon successfully for more than two centuries. With the proper incentives, American free enterprise can produce the best material, at the lowest price, and in the least amount of time. I am confident that the American military will continue working hand-in-hand with the private sector, that together we will get the job done, and that together we will continue to protect and defend the many blessings provided by our free and democratic way of life.

READY OR NOT?

The newest Air Force fighters—the F-15 shown, the F-16 and the A-10—are safer and easier to maintain than their predecessors, a counter to critics' charges that advanced weapon systems are difficult to operate and maintain, hence impair readiness.

"Despite more than $600 billion in defense spending during the first three years of the Reagan Administration, military unit readiness has declined significantly." This line was typical of a spate of articles that appeared in the nation's press in early spring; citing "Pentagon documents" as their source, they charged that the number of Army units ready for combat was down 25 percent over the three-year period, USAF ready units fell 15 percent and Naval aviation readiness was down by an unspecified degree.

Coming at a time when the Congress was just beginning to mull over the Fiscal Year 1985 defense budget, and in a Presidential election year at that, the reports created a furor, outraging defense proponents and providing ammunition for defense critics.

Were the reports accurate or fabrications? Neither, as it turned out. They were false in the basic assumption that readiness is declining despite large defense outlays. They were accurate to the extent that the numbers quoted were actually extracted from Defense of Defense documents—but the numbers were misinterpreted. It was a classic example of "a little knowledge is a dangerous thing."

The reports prompted a counter barrage from the Administration and DoD. "We don't agree with (them) in any shape, form or fashion," said White House spokesman Larry Speakes. General John W. Vessey, Jr., Chairman of the Joint Chiefs of Staff, termed the reports "not correct" and added that the military services are "far more ready today." Air Force Chief of Staff General Charles A. Gabriel concurred and stated that the facts had been "grossly misinterpreted."

What had happened, according to DoD officials, was that the purveyors of the media charges had compared apples with oranges. The documents they had seen provided not year-to-year readiness comparisons, but statistical comparison of a given unit with its readiness optimum; in other words, a unit transitioning to new

Are U.S. defense forces ready for combat? Readier than ever, say military leaders.

By JAMES J. HAGGERTY

The F-16 achieved the best safety record of any single engine fighter ever flown by the Air Force and the USAF's overall safety record for 1983 was the best in history.

equipment may get a low equipment readiness rating, but it means only that the unit is not as ready as it will be when it gets all the advanced equipment on order.

General Vessey cited an example: An Army tank battalion has its full complement of 54 M-60A1 tanks, same as it did three years ago. In the interim, it was authorized new M-1 tanks, but it has not yet received them. Under the Army's readiness reporting system, the battalion gets a low readiness mark because it does not have the M-1s *now*. But the battalion is no less ready from the equipment standpoint than it was three years ago, because it still has its 54 M-60A1s. In fact, the battalion may be more ready on an overall basis than it was three years ago because readiness involves factors other than equipment—for example, personnel training levels, communications and maintenance support.

The DoD readiness reporting system is undoubtedly confusing to the layman and subject to misinterpretation but, as General Vessey pointed out, it was not designed for public use. It is an internal management tool, used differently by each of the services, for measuring unit readiness against a temporary optimum; it is employed to decide the areas of focus for the next increases in readiness and to determine how best to use the force in operational activity. It is a useful tool, Vessey said, because the users of the system know their units and what the units can do. To them, the statistics pounced upon by the media represent only temporary relationships with a "moving target," figures that change continually as a unit in transition approaches authorized strength. What may look like statistical unreadiness to the uninitiated is actually a statement of current status relative to a goal.

So how do we really stand on readiness?

As far as the Air Force is concerned, there has been "a tremendous increase in capability since 1980," according to General Gabriel, who pegged the degree of increase at 60 percent. The USAF chief told a Congressional committee that in 1980 the Air Force had 67 fighter squadrons ready for combat and they had 15 days worth of spare parts; today there are 86 war-ready squadrons with spares enough for 30 days.

In an earlier speech, General Gabriel cited the American involvement in Grenada as an example of DoD readiness.

"We proved that we had *planning* readiness," he stated. "The whole operation was put together and was being executed in less than 48 hours.

"We proved that we had *people* readiness. Our troops—Army, Navy, Air Force and Marines—demonstrated that their joint readiness training paid huge dividends as they executed a complex operation.

"We proved we had *equipment* readiness; the airplanes, ships, tanks and guns performed as they should.

"Grenada was a very small example, but living proof that this country has the best equipped, best trained and best prepared military force in its history."

DoD is not, however, resting on its laurels. "Our Number One priority," Gabriel added, "is to improve the readiness of the forces we have. Readiness is many things. It is quality people training realistically with the best equipment we can buy. It's the spares to maintain our aircraft. It's the right munitions to do the job effectively the first time. It's a vigorous industrial base. It's hands-on training for our skilled mechanics, and it's realistic exercises that give our people the combat-like experience needed to make them proficient and keep them that way."

Safety is an integral factor in operational readiness, Gabriel said, calling the USAF flight safety record "the unsung hero of readiness." The Air Force has reason to be proud of its progress in reducing accidents. In 1982, the service achieved an all-time best flying safety record; in 1983 it not only set a new record but topped the previous year's accomplishment by a wide margin.

In 1983, the USAF lost 58 aircraft in approximately 3.4 million flying hours, which amounts to a rate of 1.73 major mishaps for each 100,000 flight hours. That compares with a 1960 rate of 5.8, with 428 aircraft destroyed or sustaining major damage; in 1950, the rate was 36.0 with 1,744 aircraft involved. As recently as 1978, the rate was 3.0 and many officials regarded that as a benchmark level that would be difficult if not impossible to improve upon—but the rate continued to drop. Most significantly, the 1983 record was attained at a time when the Air Force had one of the youngest pilot and maintenance personnel complements in recent history, and in a year when USAF crews flew in the most realistic and demanding training environments ever.

A major contributing factor underlined by General Gabriel was the performance of the newest Air Force fighters, the McDonnell Douglas F-15, the General Dynamics F-16 and the Fairchild A-10. The F-15, for example, had a "destroyed rate" half that of the predecessor F-4 at a comparable point in service; the F-16 achieved the best safety record of any single engine fighter ever flown by the USAF. These high technology aircraft, said the USAF chief, "have proven safer and more maintainable than any of their predecessors." That's an impressive counter to the often-voiced charge of some defense critics that highly sophisticated weapon systems impair readiness because their complexity makes them difficult to operate and hard to maintain.

Accident prevention is no accident; the decline in major mishaps represents an aggressive effort on the part of many people. The aerospace industry has played an important role by accenting safety in the design, production and maintainability of new aircraft. Said General Gabriel: "The real work in accident prevention goes on at all levels—designers, engineers, commanders, crew chiefs and aircrews. Designers and engineers in American industry are capitalizing on the many significant advances in aeronautics and technology to produce aircraft that are sounder to fly and easier to maintain. System safety engineering, which identifies and corrects hazards early in the design and development phases, is paying big dividends. The alternative—modification and retrofit—is expensive, time-consuming and degrades readiness. Our new fighters, developed and produced in the last decade, clearly show how paying attention up front pays off."

USAF Chief of Staff Gabriel: "Designers and engineers in American industry are capitalizing on the many significant advances in aeronautics and technology to produce aircraft that are sounder to fly and easier to maintain. System safety engineering, which identifies and corrects hazards early in the design and development phases, is paying big dividends."

At a press briefing called expressly to counter the media reports of declining readiness, Joint Chiefs Chairman Vessey insisted that the reports were "not correct." He stated: "We have better people; they're armed with more and better equipment; their training has been improved, and they have better support behind them. And that makes for a readier force."

Here is a summary of his amplifying remarks:

People. Comparing the force today with the force of three years ago, the number of high school graduates is up from 68 percent in 1980 to 91 percent in 1983. The number of people in the lowest mental category is down from 31 percent (1980) to eight percent (1983). Reenlistments are up, and the shortage of non-commissioned officers in all services has been dramatically reduced. The pilot shortage (all services) has been reduced from 5,000 to 1,200, the engineer shortage has been eliminated, and the number of Navy nuclear officers has increased by about 20 percent.

Equipment. More and better equipment for all services adds up to increases in both capability and readiness. The Army has added 14 battalions of M-1 tanks and 15 battalions of M-60A3s, tanks that are far more capable than those they replaced. Almost 1,000 first-line fighter aircraft have been added to the force and there has been an increase in helicopters, including 22 companies of (Sikorsky) Black Hawks. The Navy has commissioned 46 new ships and Army capability has been improved by the introduction to operational service of the (LTV Aerospace) Multiple Launch Rocket System. In general, said Vessey, "a significant increase in very good, modern equipment."

Training. Improvements in training techniques have upgraded the force capability. Additionally, flight training time for tactical pilots has increased; the Air Force is up 20 percent per pilot, the Navy six percent. The flying accident rate is the lowest it has ever been for all services and training is more realistic. There have been more and better training exercises, including joint exercises. All four services have begun to capitalize on research and development in training techniques and equipment, particularly weapon system simulators.

Support. The force is better supported than it was in 1980. Maintenance backlogs are down, ammunition supplies up, the spare parts situation improved and strategic mobility also improved. Sustainability funding is up about 25 percent, spares funding has doubled, ammunition funding has trebled—and that has produced a marked increase in readiness and sustainability.

Add it all up, said General Vessey, and it comes to this: "The force is simply far more ready than it was three years ago to do the things the taxpayers of this country expect it to be able to do."

℞ For Export Expansion

By DR. KARL G. HARR, JR.
President, Aerospace Industries Association

For a good part of the 20th century, the United States was the world's technology leader, a fact that contributed in great measure to the strong national economy we enjoyed for most of the century's first six decades. Our technological superiority enabled U.S. manufacturers to offer better products at lower prices, thus securing American preeminence in the world marketplace.

In the mid-1960s, however, the picture began to change. The large annual surpluses, long taken for granted, started to decline. Then, in 1971, the U.S. recorded an international trade deficit of $2 billion; significantly, it was the first U.S. trade deficit since 1888. But, unfortunately, not the last. In six of the eight remaining years of the 1970s, the U.S. posted deficits—and the amount of deficit increased dramatically in the latter years of that decade, up to more than $30 billion. The decline continued in the 1980s. Last year, the deficit was more than $60 billion—but even that horrendous figure will be a short-lived record, because all indications point to a 1984 deficit on the order of $100 billion.

Clearly, this alarming trend must be reversed—and soon—if the United States is to achieve a full and sustained economic recovery.

The matter of how to reverse the trend must be prefaced by a look at the factors that caused erosion of the U.S. trade posture. There are many, not least among them the strength of the dollar in recent years; the dollar's high value relative to major international currencies has made American products more expensive for foreign purchasers and made foreign products more attractive to U.S. buyers by virtue of the bargain prices inherent in the exchange rate. There are, however, two principal factors for focus in any strategy for rejuvenating American trade: we must further upgrade the U.S. technological capability and we must find ways to offset certain trade-enhancing advantages our competitors enjoy as a result of foreign government support of their industries.

In aerospace and other high technology industries, the U.S. is still the free world's technological leader. But, due in considerable part to reduced U.S. emphasis on research and development in the 1970s and concurrent intensification of foreign R&D efforts, the technology gap has narrowed. Additionally, what technological edge we retain is blunted by non-technical considerations. In Europe, Japan and elsewhere, governments have adopted such supportive measures as development subsidies, tax incentives, promotional aid and financial assistance in marketing, all of which undeniably enhance the attractiveness of competitors' sales packages. Thus, the U.S. faces a two-pronged challenge from abroad: the increased technological competence of our competitors and the extra measure of competitive strength they get from export-oriented support provided by their governments.

In the interest of fostering a national strategy for U.S. trade revivification, Aerospace Industries Association's Board of Governors conducted a major review and assessment of the critical problems confronting the United States in the international marketplace. From this comprehensive study came a report entitled *Trade and R&D Policies: An Aerospace Industries Association Proposal*, which offers a plan for an American response to the trade challenge.

The essence of the AIA proposal is summarized in this extract from the report:

"To buttress its sagging trade performance and remain a viable contender in the world marketplace, the United States must mount a dynamic and aggressive trade revitalization program. It must be a *positive* program that builds on American strengths while reaffirming the traditional American commitment to fair trade principles. Although some nations are erecting self-protecting trade barriers that increasingly threaten the fair and open trade environment, the U.S. must eschew protective measures that seemingly offer immediate remedy but ultimately would have serious counterproductive consequences.

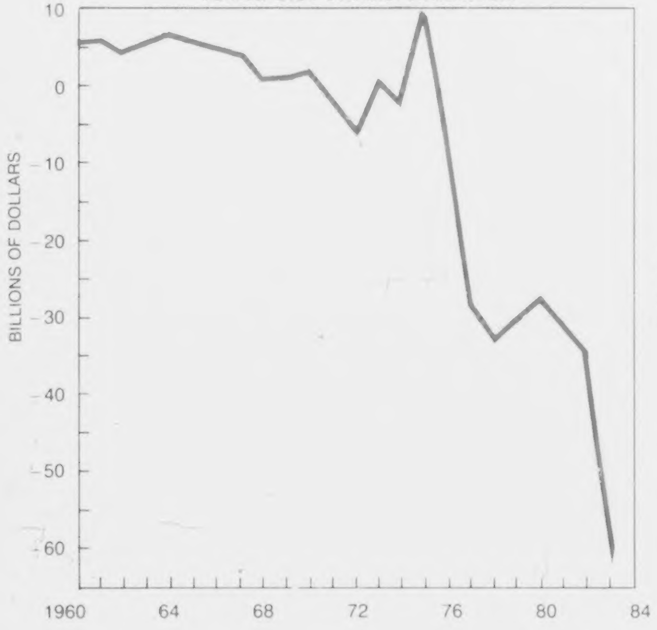
"Instead, the U.S. program should focus on reestablishing product superiority in international markets. Many of the needed tools are within our grasp. Although America has lost momentum, it has not lost its basic strengths: enormous material resources, a wealth of highly skilled manpower, a genius for innovation, a solid foundation in research and development. These are the building materials of a new thrust toward American trade preeminence. They must be supported by a stable framework of policies that allow and encourage most effective utilization of the resources."

With regard to such policies, AIA fully supports the U.S. government's continuing efforts to negotiate a more equitable international trading environment—but it would be unrealistic, even naive, to expect that we can negotiate out of existence the advantages our foreign competitors enjoy as a consequence of their governments' support. The U.S. must develop countermeasures to neutralize those advantages to the degree possible. However, given the fundamental differences between the U.S. and foreign economic and political systems, we cannot expect that the U.S. government can or will provide American export industries the same type or extent of support available to our competitors.

Therefore, AIA believes that the best opportunity for reversing the current trend in international trade lies in bold, innovative technology thrusts that will yield products of indisputable technical and economic excellence—products whose qualities outweigh whatever nontechnical marketing attractions our foreign competitors may offer and thus expand significantly the U.S. international trade volume.

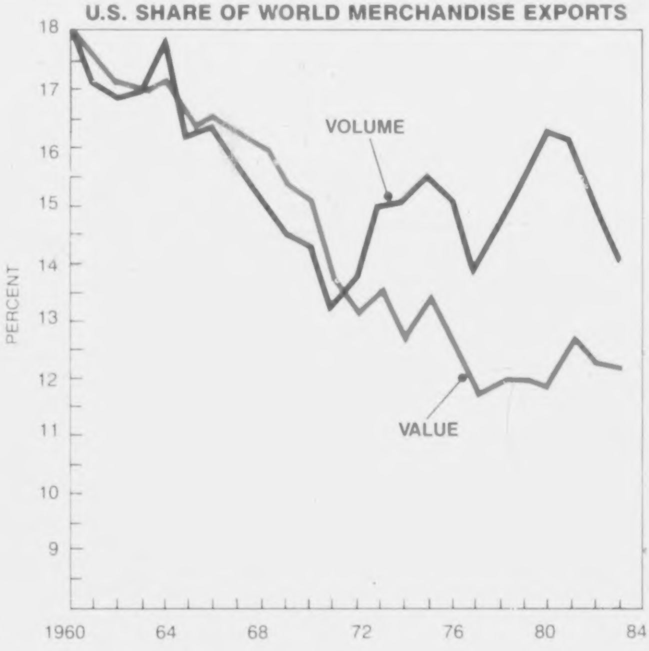
These goals are within our nation's reach and they *must* be accomplished. A prime requisite to their attainment is strong, clear focus on the two principal factors affecting U.S. performance in the world marketplace: trade policy and R&D policy.

TOTAL U.S. TRADE BALANCE



Source: U.S. Department of Commerce

U.S. SHARE OF WORLD MERCHANDISE EXPORTS

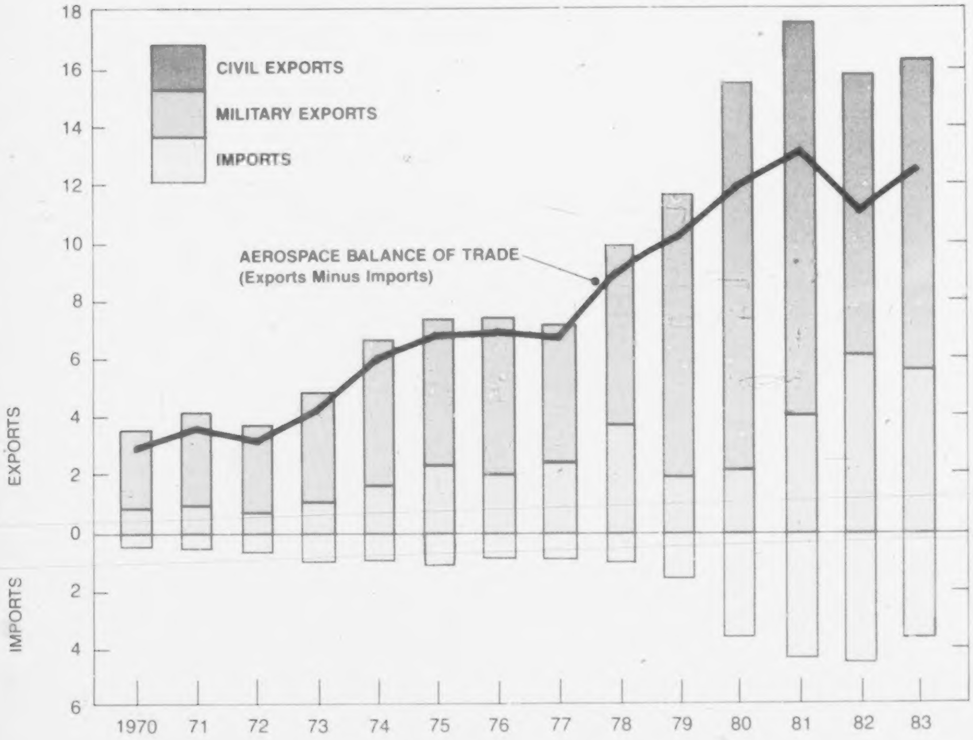


Source: International Monetary Fund, International Financial Statistics

Since 1970, the U.S. trade balance has been generally in deficit and the amount of annual deficit has increased sharply. The U.S. is also faring poorly in an important component of the overall trade balance: merchandise trade. Aerospace Industries Association offers a proposal for revitalizing American trade competitiveness.

AEROSPACE EXPORTS, IMPORTS AND TRADE BALANCE

(Billions of Current Dollars)



Source: Bureau of the Census.

Among merchandise trade components, U.S. high technology products have consistently done well in world markets; aerospace, for example, contributes a substantial positive trade balance each year and the aerospace industry is the leading U.S. manufacturing exporter.

An effective trade policy must assign a high national priority to export expansion; endorse fair and open trade, and promote adoption of equitable rules for fair international competition; create new incentives to export expansion and eliminate existing disincentives; and reflect a view of trade as a national investment in faster growth of the Gross National Product, increased tax revenues and higher employment levels.

Along with according higher priority to research and development, the national R&D policy must encourage effective cooperation among government, industry and the academic community; maintain the strengths of decentralized decision-making by industry; and provide long-term incentives toward reestablishing product superiority.

With regard to aerospace, the AIA proposal also emphasizes increasing U.S. competitiveness through new, focused technology thrusts directed toward the aerospace product line of the 1990s. The association's strategy involves an intensified R&D effort centered on certain technologies that offer future aerospace products—technologies that promise the highest payoffs for both national defense and improvement of aerospace industry international competitiveness. The types of technologies and the dramatic payoffs they promise are detailed in a companion AIA report entitled *Aerospace Technology for the 1990s;* it is summarized on page 10 of this issue.

Many of the elements of the trade and R&D policies envisioned by AIA are already in place, but they are not aggressively implemented. Key principles are often espoused, but without strong and steady commitment; regulations are broadly imposed, but without real harmonization or clear purpose. To be effective, trade and R&D policies must be mutually supportive, they must be consistently implemented, and they must have firm backing from the Administration, the Congress and the American public. Stated policy goals must be made national objectives of the highest priority and it must be recognized that attainment of such goals demands a national long-term commitment.

Trade and R&D policies must center on a more competitive government/industry relationship. The government should work to create a policy environment in which industry can function effectively and competitively. An essential government contribution is strong support of fundamental research where the risk is so high and the payoff so distant as to render it impracticable for industry undertaking. Industry, for its part, must review its own trade policies and practices from a perspective that accords high priority to exports; it must increase its R&D funding to expand the technology base toward development of superior products; and it must increase its capital investment to improve productivity and stimulate innovation.

Additionally, government and industry must work together to generate greater public awareness of the realities of an increasingly interdependent world. They must emphasize the economic benefits of exports,—particularly high technology exports—in terms of GNP, jobs and tax revenue.

Of fundamental importance, industry must be able to count on stable, continuing trade and R&D policies. A solid, *long-term* policy framework with clear objectives will allow today's U.S. industries—and those of the future—to compete aggressively and successfully in the world marketplace. If such a new national purpose can be forged, America will regain its lost competitive momentum and be assured of the economic health essential to stability, strength and national security.

Copies of *Trade and R&D Policies: An Aerospace Industries Association Proposal* are available from the Office of Public Affairs, Aerospace Industries Association, 1725 De Sales Street, N.W., Washington, D.C. 20036.

AEROSPACE TECHNOLOGY FOR THE 1990s

BY C. RONALD LOWRY
Vice President—Research and Technology
Aerospace Industries Association

The United States is facing an international trade challenge of unprecedented dimension. Through years of effort, foreign competitors have significantly upgraded their technological capabilities. Their expanded technical competence, coupled with a variety of trade-enhancing support measures provided by their governments, has been a major contributing factor to a dramatically changing international trade picture. In recent years, the U.S. has experienced large and rapidly increasing trade deficits with alarming portent for the future.

The U.S. is confronted by a similar challenge in the field of national security. The Soviet Union continues to enlarge both its force-in-being and its technological capability—and the Soviets enjoy an additional advantage in that they can commit a greater portion of their resources to military expansion than is practicable in a free society.

The best opportunity for simultaneously reversing the trade trend and strengthening national defense lies in bold and innovative technology thrusts for the 1990s. That is the opinion of AIA's Aerospace Technical Council, which offers a plan for sharply upgrading U.S. trade competitiveness and defense capability. Detailed in a recently published report entitled *Aerospace Technology for the 1990s*, the AIA plan envisions an intensified and *focused* research and systems technology effort aimed at the aerospace product lines of the 1990s. The term "focused" in this context means concentration on certain technologies that offer potential for really significant improvements in the cost and performance of future aerospace products. When combined and integrated into new systems, these technologies promise the greatest payoffs to the U.S. trade and defense postures.

The report is the result of several months study by senior aerospace industry experts. It identifies the technologies of high payoff potential, demonstrates their applicability to both military and commercial systems, relates the possible technological advances to selected end products of the 1990s, and summarizes anticipated cost and performance benefits.

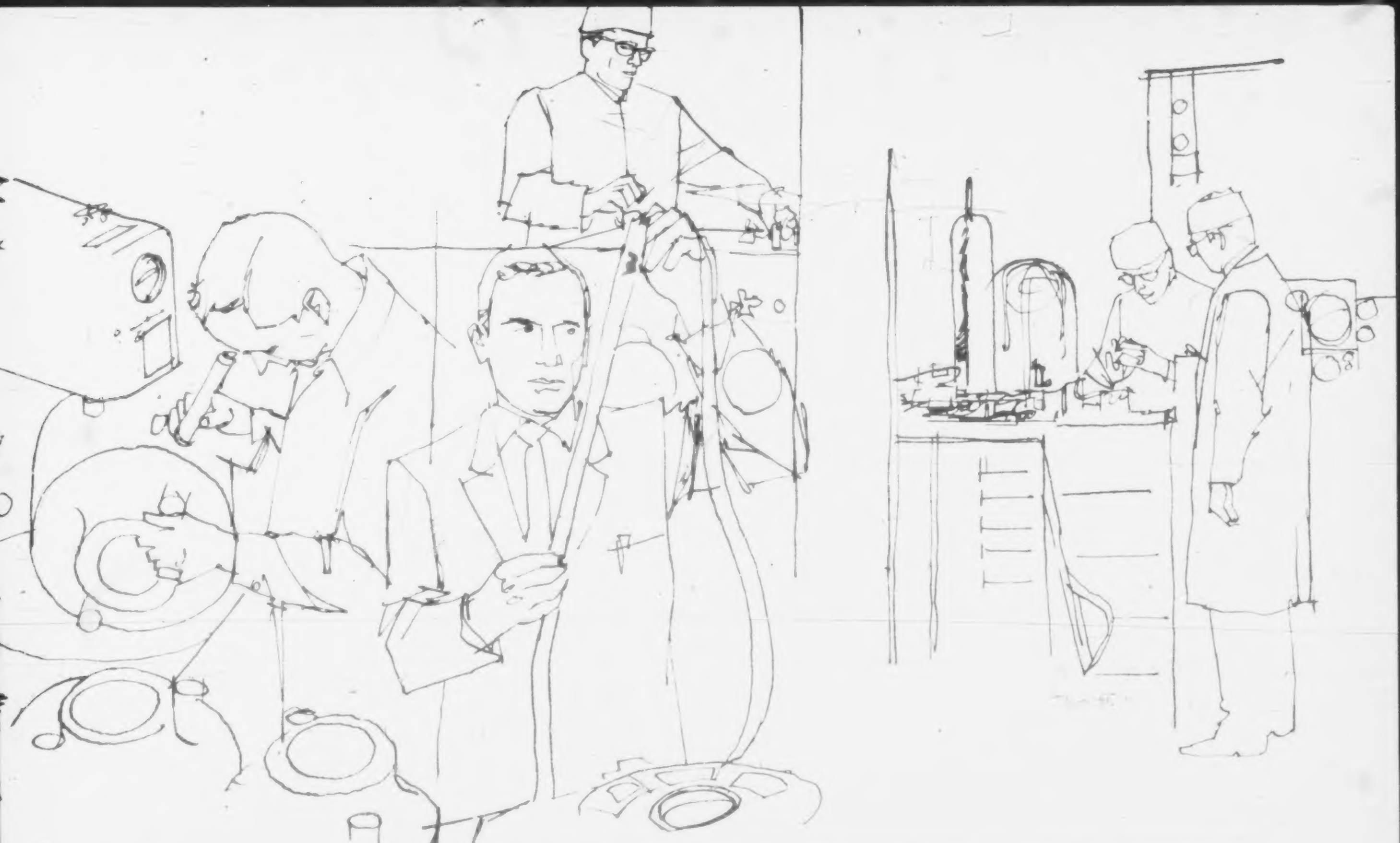
The Tech Nineties report states that "current trends show a convergence of U.S. and foreign technological competence in many aerospace product lines." It cites as examples of improved foreign technical competence the Airbus jetliner series, new foreign-built commuter transports, the Ariane space launch vehicle, European helicopter advancements and the new generation of Soviet military aircraft.

"Nonetheless," says the report, "a dramatic upward change in the U.S. technology progress curve can be effected through more aggressive development and exploitation of aerospace technology for the 1990s, a new trajectory that would provide vast improvements over systems of the 1980s. Along with greatly increased performance and reliability, it appears possible to achieve operating cost improvements of 30 percent to 50 percent for new aircraft, as much as tenfold improvements in effectiveness for some space systems, plus altogether new capabilities in such fields as unmanned aircraft and command, control and communications intelligence (C^3I).

"Gains of such order promise immense benefit to the U.S. Obviously, the combination of greater product capability and sharply reduced costs would have tremendous impact on U.S. competitiveness in both commercial and military product lines; U.S. product superiority could be reestablished where it has eroded, expanded where it still exists."

The AIA focused technology plan includes, in addition to performance-enhancing technologies for individual systems, concentration on cost superiority through emphasis on designing to cost, advanced manufacturing technology, more productive "factories of the future," and a better motivated work force – all management challenges for the aerospace industry.

The stakes are high. Defense considerations aside, the aerospace trade potential for coming years is of exceptional order. For example, the 1990s world market for subsonic aircraft alone, military and commercial, is estimated at more than $200 billion. This market includes all commercial transports from business jets and commuter aircraft to intercontinental jetliners, together with military intratheater and strategic airlifters, tank-



ers and land-based and carrier-based antisubmarine warfare aircraft. In the 1990s, the market may include long-enduranace aircraft and stealth aircraft for various missions, in addition to advanced successors of currently operational aircraft.

To compete successfully for this and other aerospace markets, says the Tech Nineties report, the U.S. must insure a strong and growing aerospace posture through more aggressive industry, government and university technology programs, backed by enlightened research and development and export policies at the national level, and supported by stable, long-term priorities. Meeting the goal will also require better long-range planning and increased funding by both government and industry for technology of the 1990s. The report concludes:

"If such a strategy is adopted, sustained and vigorously supported by accelerated government and industry investment in computer-aided design and engineering and computer-integrated manufacturing, and backed by progressive work force management for increased productivity, the United States can simultaneously effect a stronger defense capability and a position of clear-cut product superiority in international aerospace trade—a goal technically capable of accomplishment and one whose broad benefit potential fully justifies the requisite support and investment."

ANTICIPATED BENEFITS

Examples of benefits attainable through focused R&D and integration of advanced technology in aerospace products of the 1990s include:

Long-range transport (military or commercial): a productivity gain of 80,000 ton miles a day, an increase of 30 percent over today's aircraft; a 50 percent increase in payload/range; a 30 percent reduction in life cycle cost. The bottom line: $9 billion less for a fleet of 100 aircraft over 20 years of operation.

Short-haul transport: a 65 percent reduction in fuel consumption; a 43 percent reduction in direct operating costs ($3 million per year per aircraft); increased airport compatibility and fewer air traffic delays.

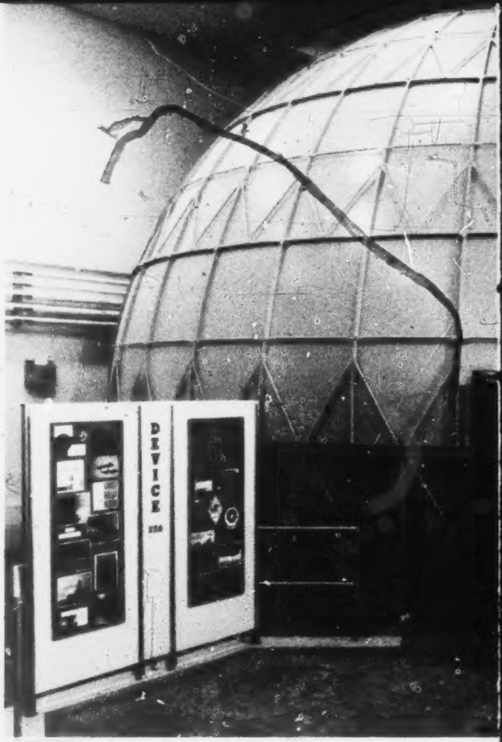
Air superiority fighter: a 20:1 improvement in mission effectiveness; a 2:1 improvement in availability; a 25 percent reduction in life cycle cost; $14 billion less for a fleet of 1,000 aircraft over 20 years.

Rotorcraft: an operating cost reduction of 50 percent for helicopters, up to 80 percent for hybrid rotorcraft; speed and range increases of 30 percent for helicopters, 100 to 200 percent (relative to helicopters) for hybrids; reduced vibration, noise and detectability; increased safety.

Tactical C^3I: increased communications security, reliability and survivability; information management at unprecedented speeds; dramatically quickened response to enemy counterthrusts through more direct linking of target sensors with weapons; detection and identification of hostile air vehicles at long ranges and all altitudes under day, night and all weather conditions.

Satellites: up to tenfold improvement in effectiveness.

THE ADVANCING ART OF SIMULATION



By LAURA OVERSTREET

Simulation, according to one dictionary definition, is the art of imitating a form or condition. That's generally accurate, but it doesn't go far enough in describing modern simulation systems produced by the aerospace industry. Today's simulators have reached such a degree of sophistication and realism that they are often better than the real thing from the standpoint of cost-effective training or engineering design productivity.

Aircrew training, traditionally the principal use of simulators, is still one of the primary aerospace applications; pilots or crews can be put through a variety of emergency situations or familiarized with a new model airplane without ever leaving the ground. But there is growing employment of simulators in other aerospace applications. For example, engineers can analyze and modify new weapon systems during the design phase, when changes are less costly; astronauts can prepare for space missions with a degree of realism achievable in no other way; military researchers can study the physiological reactions of weapon system operators and apply such knowledge to the design of future systems. And simulation is by no means limited to aerospace use; its utility now spans a broad spectrum of nonaerospace applications such as ship, tank or railroad training systems and power plant, oil refinery and industrial process operations.

Simulation has become a big business, worth something more than $1 billion annually in the U.S., although market estimates are vague. Simulators for military purposes alone constitute a billion dollar market, according to Bill Turner, president of Link Flight Simulation Division of The Singer Company, the world's largest producer of simulation systems. One indicator is the fact that the U.S. Air Force plans to spend $149 million in the next fiscal year to build prototype simulators for aircraft systems.

A major reason for the growth of simulation activity is its savings potential. The Boeing Company estimates savings of 100 to one where an engineering simulator can be used in lieu of actual flight tests. Costs for training in a B-52 simulator at Griffiss Air Force Base, New York are reportedly between five and 20 percent of the cost of flying. Savings are realized not only in dollars but in time. Simulation in engineering design means that weapon systems are mission oriented right from the start, with built-in integration of airframe, weapons and aircrew considerations. Design validation can be accomplished as the aircraft progresses, rather than waiting for tests of a prototype.

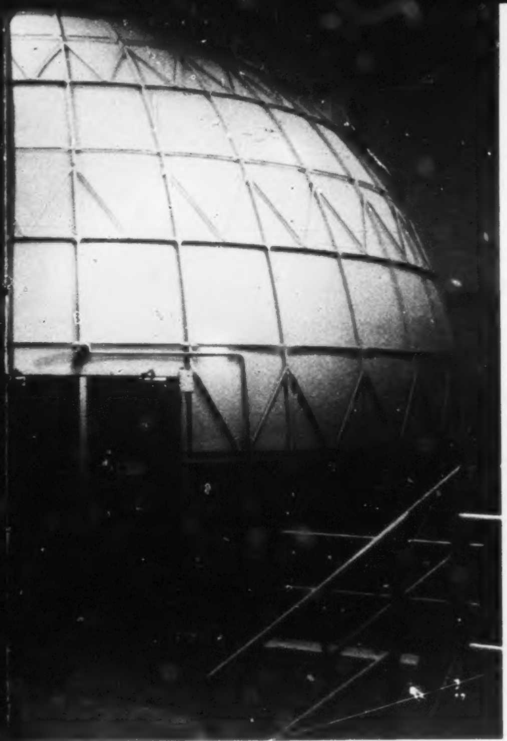
According to Sperry Corporation, the second largest producer of simulators, the effectiveness of simulator training depends primarily on two basic elements: fidelity of the environment provided to the trainee, and accessibility and control available to the instructor.

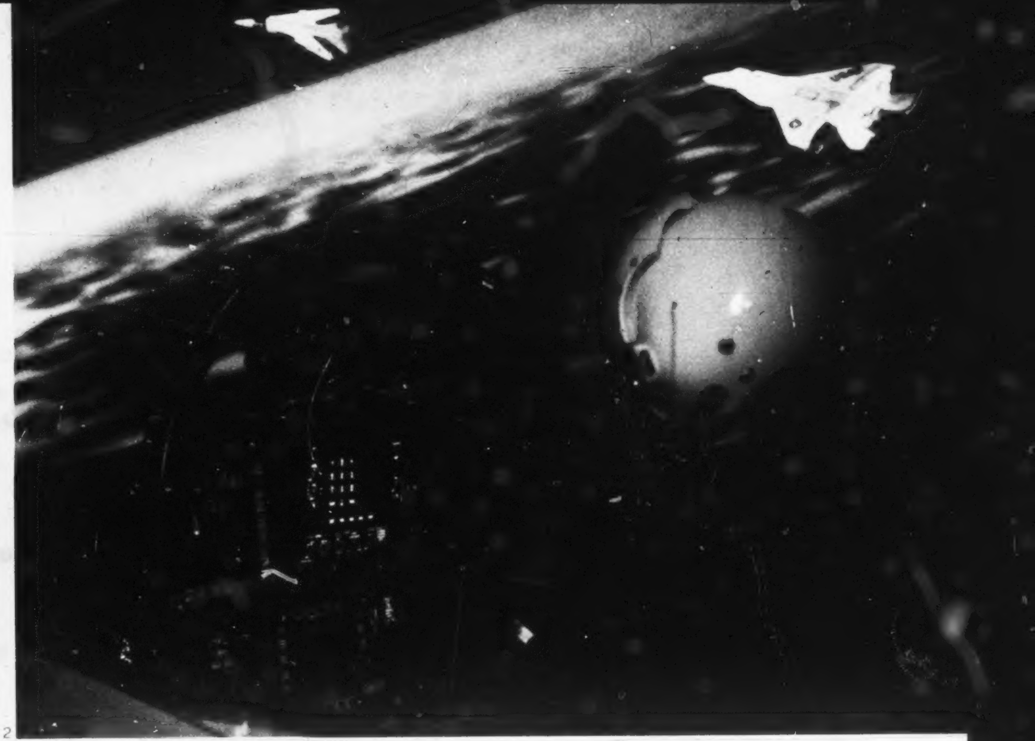
Simulators vary considerably in their degree of sophistication; they range from stationary cabins on a fixed base to advanced, computer-directed systems with six degree freedom of motion bases. All simulators have these common advantages: they are ultimately money saving, time saving, and they provide immediate feedback to the designers, instructors and operators that use them.

Simulation has come a long way from the famed Link "Blue Box" used in World War II for pilot training; experts say the art has advanced more in the past six years than in the previous 25. Competition for market position in today's simulator industry can depend on subtleties such as the degree of realism with which the outside visual environment is reproduced. This realism can be computer-generated, laser-generated, or produced by a closed circuit television probe roving over a large terrain model. Realism can include such detail as night scenes of an airport runway showing lights increasing in intensity as the aircraft approaches, weather effects, and buildings vertically obscuring one another according to a visual reference point.

As sophisticated as simulators have become, they are machines of little use without people in the equation. This important concept of "man in the loop" from the design to the training phases has been reiterated by General Robert T. Marsh, Commander, Air Force Systems Command, who says that the final product in a training device is not hardware but a fully trained man or woman.

The goal of the aerospace industry in producing simulators is to employ the realism that modern technology makes possible to engineer systems that are man-centered from the start and that will help turn out fully trained individuals with the skills and behavior patterns needed to accomplish their jobs—whether the jobs involve military combat, landing of a commercial airliner in adverse weather conditions, or the efficient operation of an industrial powerplant. The following pages contain a representative sampling of simulation systems manufactured by aerospace industry companies.





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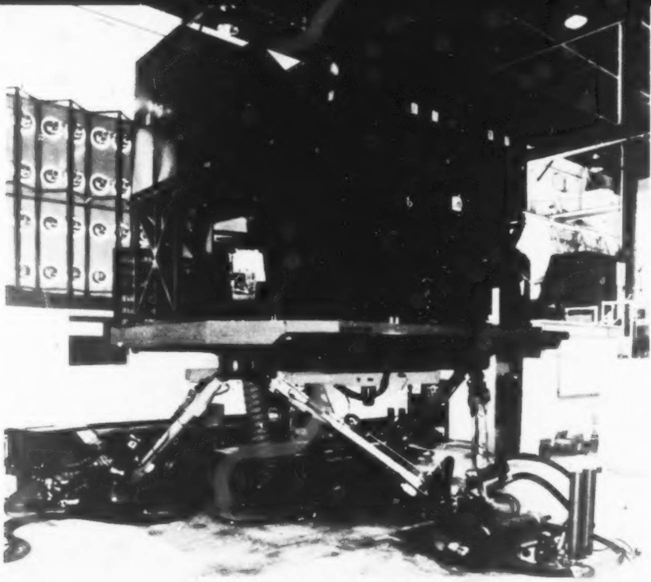
1.-2. Within the spherical enclosure (1) at McDonnell Douglas Corporation, pilots enact combat maneuvers from any one of four fighter aircraft cockpits—F-18, F-15, AV-8B or F-4—as an aid to weapon system design. For manned air battle simulation, up to seven visual images can be displayed simultaneously on the dome surrounding the cockpit (2). Countermeasures and weather can be simulated at will; opponents are varied to represent current and projected enemy threat. As the engagement progresses, the weapon system designer—at controls outside the simulator—assesses the pilot's actions and comments relative to total system operation. This "man in the loop" method of designing weapon systems is used by most developers because of its instant feedback; modifications can be made before prototype completion, saving both time and money.

3. At the Flight Simulation Laboratory of General Dynamics' Research and Engineering Department, a client USAF pilot is evaluating both the airframe and avionics being developed for advanced fighter aircraft. Because it is difficult to replicate all the maneuvers of a high performance airplane using motion base, engineers create the feel of flight with sophisticated visual effects. Systems now being developed will simulate night and low weather conditions and incorporate infrared and radar displays.

4. The instructor/operator at the computer controls is vital to programming of simulator missions. Here a Hughes Aircraft Company technician is simulating aerodynamics, targets, weapon systems and attack geometry in an aerial battle being fought on the Hughes-built Weapons Tactics Trainer, a system that provides Navy and Marine Corps F/A-18 pilots with 360-degree Earth-sky imagery.



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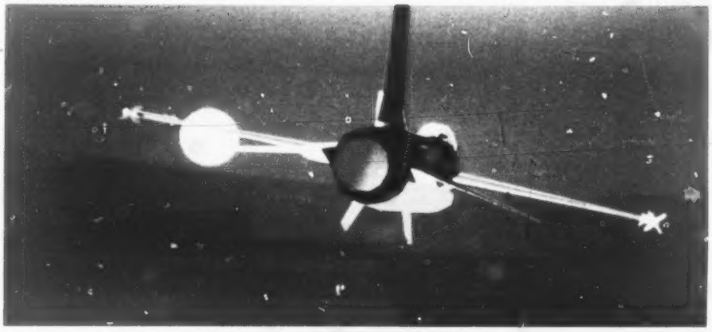

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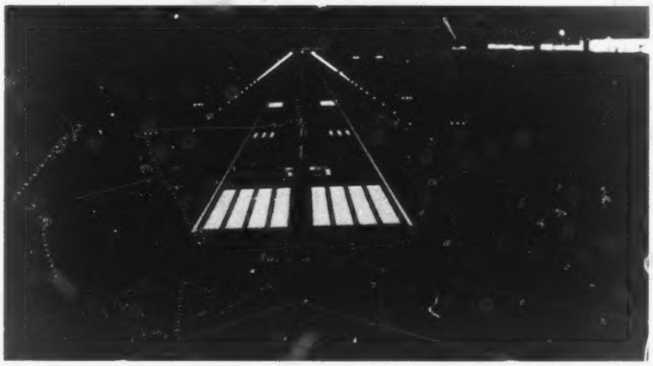

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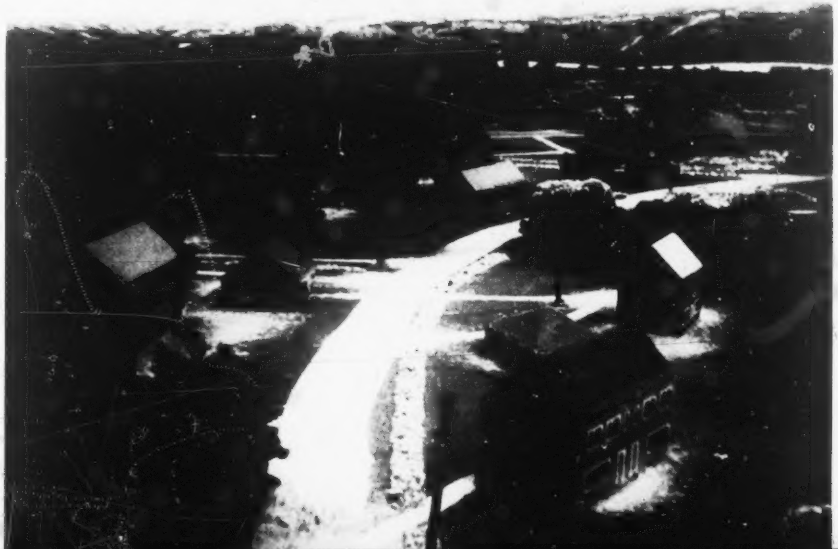
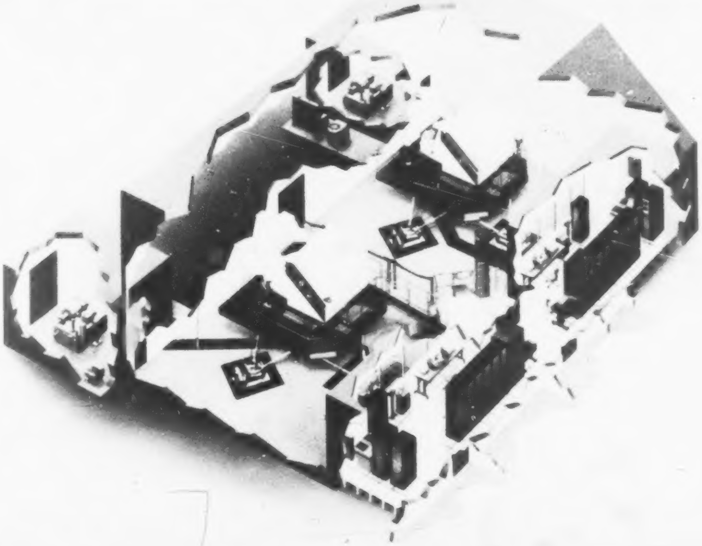


5. This CH-47C helicopter simulator utilizes Advanced Simulation Technology (AST) motion systems developed by Link Flight Simulation Division of The Singer Company. AST systems are capable of six degrees of freedom, including lateral, vertical, longitudinal, yaw, pitch and roll motion. This capability provides trainees with acceleration cues experienced in normal and emergency flight maneuvers and affords maximum simulation fidelity.
6. Singer-Link's family of Visulink visual display systems includes the Digital Image Generator (DIG) System, which produces 1,000-line computer-composed color scenes—such as this view of an F-16 flying into the sunset—for a broad variety of training applications.
7. Singer-Link's Night Visual System is a simulator attachment that provides computer-generated night and dusk scenes in full color. This digitally-generated view of an airport runway reacts continuously to the pilot as he makes his landing, the scene changing in accordance with the changing visual reference point. Night scenes include light points, runway markings, horizon glow and other realistic effects.
8. This is a pilot's-eye view created by the world's first full-color Laser Image Generator (LIG), a visual system now in production at Singer-Link for use on the U.S. Army TOW Cobra AH-15 flight/weapons simulator. The LIG system provides high resolution detail at all altitudes and allows pilots to fly "nap of the Earth" training missions in a highly realistic environment; it can also duplicate weapons effects. A multicolored laser beam scans a detailed model board representing the pilot's field of view; light reflected from the board is detected by a bank of photomultipliers to provide the video input to the display.



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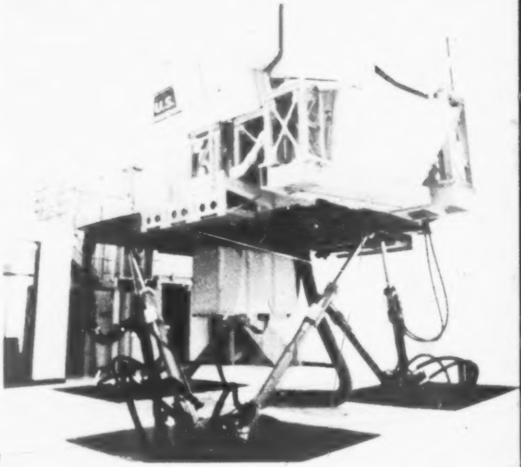

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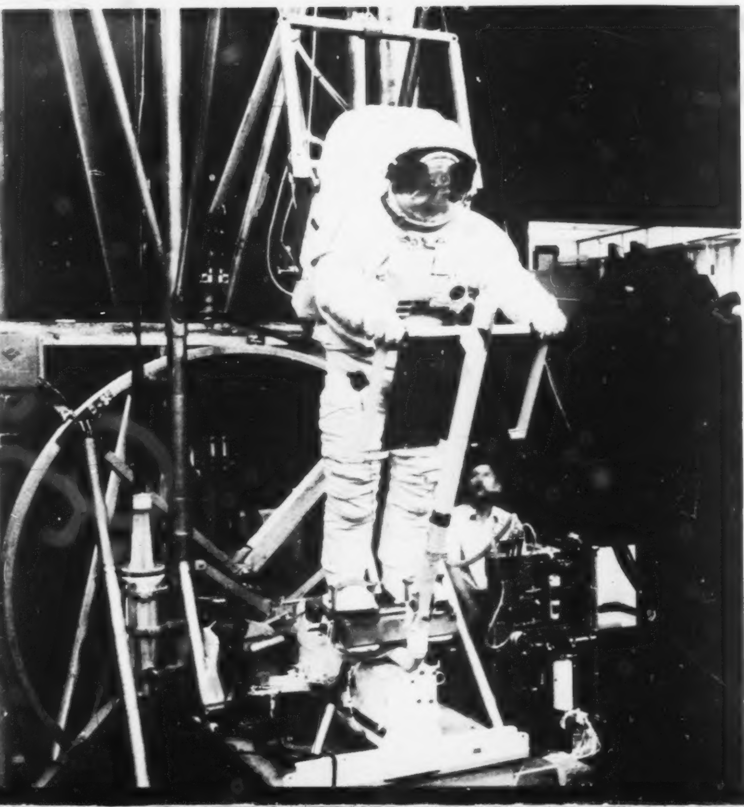

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9. This cutaway view shows the layout of a dual-unit simulator system built by Sperry Corporation for training U.S. Coast Guard pilots of the HH-65A search/rescue helicopter and the HU-25A all-weather search aircraft. Instructors at consoles adjacent to the training cabins employ six degree freedom of motion, computer-generated imagery and hydraulically loaded controls to provide almost all of the physiological cueing experienced in actual missions.

10. The Sperry/Marine Corps CH-53 Operational Flight Trainer exemplifies the degree of fidelity attainable with modern simulation systems. Compared with actual flight performance of the CH-53 helicopter, the trainer duplicates flight characteristics with accuracies on the order of 98 percent.

11. The Boeing Company's 707 simulator incorporates three degrees of motion (pitch, roll and heave), electro-hydraulic control force feel and an advanced day/night visual system. Its realism enables commercial pilots to transition from one aircraft to another with a requirement—after simulator training—for only a single flight of an actual airliner. Boeing estimates the cost differential between aircraft use and simulator training at as much as 100 to one. Boeing's Renton (Washington) Flight Simulator Center includes cabs for 747, 757 and 767 jetliners.

12. Representative of many types of space simulation systems is Grumman Aerospace Corporation's Large Amplitude Space Simulator. Here NASA astronaut is testing the Grumman-built work platform he later used on the 10th Space Shuttle flight earlier this year.

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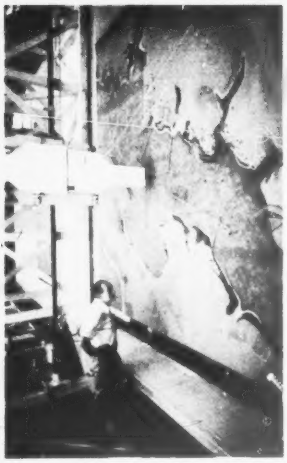

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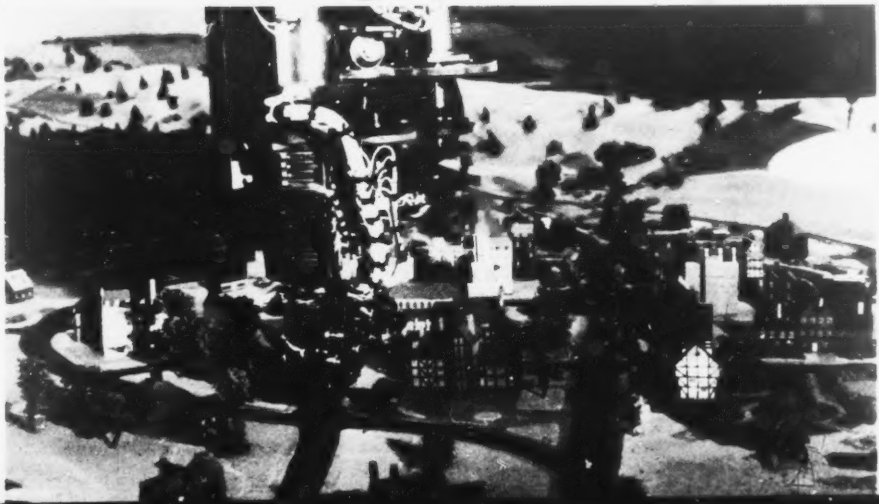

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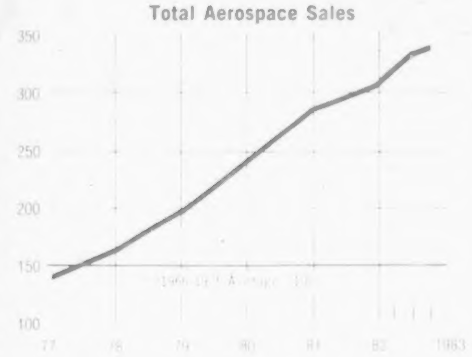
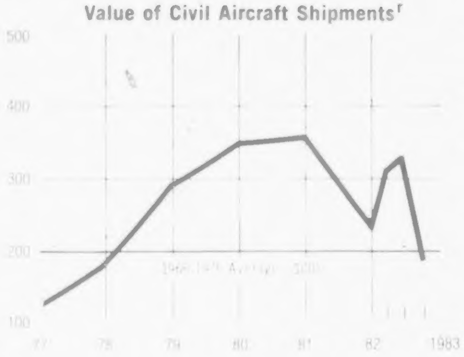
13. This cockpit view of Singer-Link's B-52 simulator illustrates the visual effects of a B-52 rendezvous with a KC-135 tanker provided by computer-generated imagery. All imagery is correlated so that the crew perceives the same depictions out the window and on the cockpit sensor displays. Correct correlation and perspective are maintained throughout a mission, from takeoff to landing.
14. Designed and developed by Sperry Corporation, the Computer-Aided Operations Research Facility (CAORF) at the U.S. Merchant Marine Academy uses a full-scale mockup of a ship's bridge fitted with controls and computerized equipment to simulate, through sight and sound, a wide range of navigational traffic situations and environmental conditions. CAORF is a research tool employed by the Maritime Administration to learn more about how sea accidents are caused.
15. A companion Sperry-built Shiphandling Simulator is used for training bridge crews by Marine Safety International, Inc. at LaGuardia Airport, New York. Visual imagery is provided by a four camera, wide angle TV probe that moves across a three-dimensional model board of the simulated geographical area; the probe's image is then projected onto a large curved screen to provide a dynamic scene that can include traffic, topographical and physical features of many different harbor areas.
16. This motion platform at Rockwell International's Autonetics Marine Systems Division holds a full-size submarine control station. Capable of replicating all the static and dynamic conditions that influence a real submarine, the simulator is used to train subcrews and to test control room design changes.
17. A closed-circuit TV camera probe scans a terrain model, providing visual cues for the operator within the cabin of a digital tank simulator developed by Link-Miles Division of The Singer Company (U.K.) Ltd. Link-Miles has produced a number of other simulators for tanks, combat engineer tractors and personnel carriers.

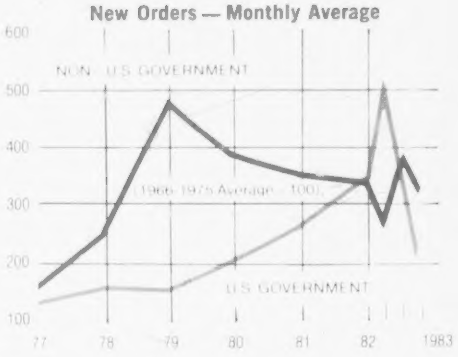
AEROSPACE ECONOMIC INDICATORS

CURRENT


Total Aerospace Sales


Value of Civil Aircraft Shipments[r]

OUTLOOK


New Orders — Monthly Average

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD**	LATEST PERIOD 3rd QTR 1983
AEROSPACE SALES: TOTAL	Billion $	Annually***	24.2	73.8[r]	79.7	80.9
(as reported by the Bureau of the Census)	Billion $	Quarterly	6.1	19.4[r]	20.8	20.6
AEROSPACE SALES: TOTAL	*Billion $*	*Annually****	*25.6*	*36.1*[r]	*37.7*	*37.4*
(in constant dollars, 1972=100)	*Billion $*	*Quarterly*	*6.4*	*9.3*[r]	*9.7*	*9.5*
AEROSPACE PRIME CONTRACT AWARDS: TOTAL	Billion $	Quarterly	5.8	20.1[r]	23.9	16.4
U.S. Government	Billion $	Quarterly	4.1	13.6[r]	15.1	9.1
Other Customers	Billion $	Quarterly	1.7	6.5[r]	8.8	7.3
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	99.2[r]	117.6	113.8
U.S. Government	Billion $	Quarterly	15.9	52.9[r]	73.6	69.6
Other Customers	Billion $	Quarterly	12.7	46.3[r]	43.9	44.2
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	5,727	7,148	8,726
Aircraft Procurement	Million $	Quarterly	1,986	4,354	5,733	6,315
Missiles Procurement	Million $	Quarterly	726	1,373	1,415	2,411
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	5,491	6,607	6,549
Aircraft Procurement	Million $	Quarterly	1,741	4,464	5,400	5,121
Missiles Procurement	Million $	Quarterly	664	1,027	1,207	1,428
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	1,276	1,675	1,429
Expenditures	Million $	Quarterly	789	1,076	1,333	1,395
EXPORTS						
Total (including military)	Million $	Quarterly	1,038	3,372	4,357	3,427
New Commercial Transports	Million $	Quarterly	345	648	1,477	606
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	1,151	1,145	1,152
Aircraft	Thousands	End of Quarter	650	591	576	577
Missiles & Space	Thousands	End of Quarter	114	134	142	146
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	11.34[r]	11.73	11.88
PROFITS (after tax) BASED ON SALES						
Aerospace	Percent	Annually***	2.7	3.3	3.5	3.5
	Percent	Quarterly	2.7	3.8[r]	4.1	3.6
All Manufacturing	Percent	Annually***	4.8	3.9	3.4	3.6
	Percent	Quarterly	4.8	3.5	4.2	4.3

Source: Aerospace Industries Association

*1966-1975 quarterly averages are computed as one-fourth of annual averages

**Preceding period refers to quarter preceding latest period shown

***Annual data are computed as the sum of the previous four quarters

r Revised

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St. N.W. Washington, D.C. 20036

AIA

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  - Chandler Evans Inc.
  - Menasco Inc.
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  - ITT Defense Communications Division
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  - Bell Helicopter Textron
  - HR Textron Inc.
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- United Technologies Corporation
- Western Gear Corporation
- Westinghouse Electric Corporation
  - Energy & Advanced Technology Group
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- Close Encounter With a Comet
- Free Trade Under Attack: What America Can Do

Notable views of notable people on aerospace matters...

aerospace perspectives

Jean-François Revel, *French political commentator, in his book How Democracies Perish, published by Doubleday & Co.:*

"Democracy probably could endure if it were the only type of political organization in the world. But it is not basically structured to defend itself against outside enemies seeking its annihilation, especially since the latest and most dangerous of these external enemies—Communism—parades as democracy perfected when it is in fact the absolute negation of democracy, the current and complete model of totalitarianism.

"Democracy is by its very nature turned inward. Its vocation is the patient and realistic improvement of life in a community. Communism, on the other hand, necessarily looks outward because it presides over a failed society and is incapable of engendering a viable one. The *nomenklatura,* the body of bureaucrat-dictators who govern the system, has no choice, therefore, but to direct its abilities toward expansion abroad. It is also more skillful, more persevering than democracy in defending itself. Democracy tends to ignore, even deny, threats to its existence because it loathes doing what is needed to counter them. It awakens only when the danger becomes deadly, imminent, evident. By then, there is either too little time left for it to save itself, or the price of survival has become crushingly high . . .

"It seems, then, that the combination of forces—at once psychological and material, political and moral, economic and ideological—intent on the extinction of democracy is more powerful than those bent on keeping it alive. Democracy is not given credit for its achievements and benefits, but it pays an infinitely higher price for its failures, its inadequacies and its mistakes than its adversaries do.

"Indeed, democratic civilization is the first in history to blame itself because another power is working to destroy it. The distinguishing mark of our century is not so much Communism's determination to erase democracy from our planet, or its frequent success in pursuing that end, as it is the humility with which democracy not only consents to its own obliteration, but contrives to legitimize the victory of its deadliest enemy."

Russell E. Dougherty, *editor in chief and publisher of Air Force magazine, in an editorial in that publication:*

"I have just reread the Declaration of Independence. It does not speak of war and peace. It defines rights of people and governments and declares denial of those rights unacceptable. That is a declaration to which our American political ancestors pledged their lives, their fortunes and their sacred honor. The current generation of Americans should do no less."

Caspar W. Weinberger, *Secretary of Defense, in a speech to the National Urban League Conference in Cleveland, Ohio:*

"In the past few years, it has been popular for critics of our defense program to . . . argue that stronger defense budgets mean weaker economic growth, fewer jobs and higher inflation. But if this premise is true, why did this nation enjoy unprecedented prosperity during the 1960s, when defense spending—both as a share of the federal budget and as a share of the Gross National Product—was much higher than today? And if this premise is true, why was there *no* corresponding economic boom during the 1970s, when defense spending declined 20 percent in real terms? . . . I am not contending that higher defense budgets produce higher economic growth. It is simply my point that a strong defense budget, if the world situation requires it, is *not* incompatible with economic growth."

Ruben F. Mettler, *chairman of the board and chief executive officer of TRW Inc., in a speech to the National Press Club, Washington, D.C.:*

"There is a comforting but highly fallacious theory that we can relax because we are simply passing through a transition from industrial to post-industrial society, and that we can safely leave manufacturing and process industries to other parts of the world, while we specialize in knowledge and service industries. Or that we can simply move beyond basic industries to 'high tech' products. (Who needs steel, auto or machine tool industries? Who needs domestic farm equipment or consumer goods industries?)

"This 'megatrend' view is simply wrong. Service industries are indeed of growing significance and, of course, developing and using advanced technology in both new products and new manufacturing processes is vital. But the evidence is clear that manufacturing industry—which has steadily accounted for one-fourth of our GNP for the past 20 years—is the core that sustains and nurtures our high technology and service industries and many related jobs. We can't sit back and watch while they die on the vine. A core of strong and healthy basic industries that can compete in world markets is an essential element of a growing competitive economy.

"The challenge is to integrate into all kinds of industrial manufacturing plants the most advanced technologies in metallurgy and new materials, microelectronics and process control, computer-aided manufacturing, expert systems and artificial intelligence, and more, in a market-driven and cost-effective way."

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CONTENTS

2 FREE TRADE UNDER ATTACK
By Dr. Murray P. Weidenbaum

8 CLOSE ENCOUNTER WITH A COMET
By James J. Haggerty

12 TECHNOLOGY TRANSFER AND NATIONAL SECURITY
By Dr. Roland W. Schmitt

14 STUDENT EXPERIMENTS ON THE SPACE SHUTTLE
By Ellen Kelly

On the cover: Artist James J. Fisher's impression of NASA's International Cometary Explorer en route to a close encounter with Comet Giacobini-Zinner *(see page 8).*

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Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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THE U.S. TRADE DILEMMA

BY KARL G. HARR, JR.
President, Aerospace Industries Association

This year the U.S. International trade deficit will reach an all-time high. That's not a prediction, it is a fact; in the first seven months of 1984, the merchandise trade deficit exceeded the total for all of 1983—and 1983 was itself an all-time high. Expert opinions vary as to the extent of this year's deficit but consensus puts it at more than $100 billion and some think it might reach $140 billion, a figure that would more than double last year's record.

Such continuing and growing trade deficits pose a problem that approaches crisis proportions. Much of the deficit, of course, is due to high U.S. interest rates and the high value of the dollar relative to the currencies of our trading partners, which makes U.S. products more expensive abroad and competing foreign products less expensive here. As the U.S. economic rebound slows and world economic recovery gains momentum, we can expect some adjustment of exchange rates, hence some amelioration of the U.S. trade problem. But much of the problem will remain, for the blunt fact is that America has lost competitive strength in a number of its industrial sectors.

As the deficits grow, there are more and more pleas for protectionism—erection of trade barriers through tariffs, quotas, "domestic content" legislation or other devices intended to protect certain segments of U.S. industry from competitive imports. In fact, says the distinguished economist Dr. Murray Weidenbaum in the lead article of this issue of *Aerospace,* the U.S. may be taking the lead in the international rush toward protection, despite lip service to the contrary. Protectionism, Dr. Weidenbaum stresses, is not the answer; it is a two-edged sword that may reduce imports to a degree but may also stimulate retaliatory actions by other countries that could worsen our trade problem.

The aerospace industry concurs. Over the long term, protectionism will inevitably weaken, rather than strengthen, the U.S. international trade posture. Rather than resorting to such negative measures, the U.S. should adopt a positive approach to improving its trade competitiveness, an approach based on American strengths—enormous material resources, demonstrated excellence in research and development and a wealth of highly skilled manpower. These building blocks should serve as the base for an aggressive program of innovative technology thrusts aimed at development of products indisputably superior to those of our foreign competitors. Only in this way can we regain market share in areas where we have lost it and expand the U.S. share in areas where we are still competitive.

In effecting such a turnaround, high technology products are particularly important. Despite reduced American R&D in the 1970s and concurrent intensification of foreign R&D, the U.S. still enjoys leadership in high technology manufacture and U.S. hi-tech products—in particular aerospace products—have consistently done well in the international marketplace. There is gratifying evidence of the excellence of American aerospace products in this fact: in the first four years of the 1980s, when the U.S. suffered trade deficits totaling more than $150 billion, the adverse impact of such deficits was substantially softened by an offsetting aerospace trade surplus approaching $50 billion.

Reversing the international trade trend is not a job for the aerospace industry alone, or hi-tech industries, or even all U.S. industry. It must be a national effort, centering on a more cooperative relationship between industry and government, each firmly committed to improving U.S. competitiveness and each fulfilling the role for which it is best suited. A prime requisite is a clear focus on trade and R&D policies. Such policies must, among other things, accord exports high national priority, endorse free, open trade and repudiate protectionism, eliminate existing disincentives to export expansion and create new incentives, particularly effective long-term incentives that stimulate industrial development of superior products. Revitalizing U.S. trade will require increased investment by both industry and government, but it is an investment that promises significant payoff in higher employment levels, increased tax revenues, faster GNP growth and continuing low levels of inflation.

FREE TRADE UNDER ATTACK: WHAT AMERICA CAN DO

BY MURRAY L. WEIDENBAUM

A noted economist offers a strategy for reasserting American leadership in free trade

One of the nation's foremost authorities on the effects of government regulation on free enterprise, Dr. Murray L. Weidenbaum is the Mallinckrodt Distinguished Professor of Economics at Washington University, St. Louis, Missouri and director of the university's Center for the Study of American Business. In 1981-82, Dr. Weidenbaum served President Reagan as Chairman of the Council of Economic Advisors. In earlier years, he was Assistant Secretary of the Treasury for Economic Policy, a fiscal economist in the Bureau of the Budget, and a corporate economist with The Boeing Company. This article was adapted from his presentation at Hillsdale (Michigan) College as part of the Ludwig von Mises Distinguished Lecture Series in Economics.

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The sad fact is that the open trading system of the free world is under attack at home and abroad by rising protectionist pressures. It is especially important, therefore, that we reinforce our intellectual defense of the free market, especially its international dimensions.

The case for free trade is rooted in a basic economic law: the principle of comparative advantage, which holds that total economic welfare will be enhanced if each nation specializes in the production of items that it can produce—in relative terms—most efficiently.

The benefits of free trade are:

1. Open trade contributes to lowering inflationary pressures by increasing the supply of goods and services competing for the consumer's dollar. Thus, the question of free trade is basically a consumer issue, and an extremely important one.
2. Open trade minimizes the role of government in influencing private-sector decisions. This allows individuals and business firms to respond to the needs and pressures of the international marketplace. Viewed in this light, free trade is key to promoting economic freedom and the private-enterprise system.
3. Open trade improves the efficiency with which our own resources are allocated. Thus, we can see that free trade yields more growth, higher levels of employment, and an improved living standard here at home.

Aside from the direct and measurable aspects, trade stimulates competition, stirs creative energies, rewards individual initiative, and increases national productivity. Among nations, it speeds the exchange of new ideas and advanced technology. In the long run, international trade means the creation of new jobs and the reduction of inflation.

In this time of great interest in benefit/cost analysis, we may inquire as to what are the costs of free trade as well as the benefits. The obvious costs are those borne by the workers who become unemployed as a result of imports—assuming that imports are the cause.

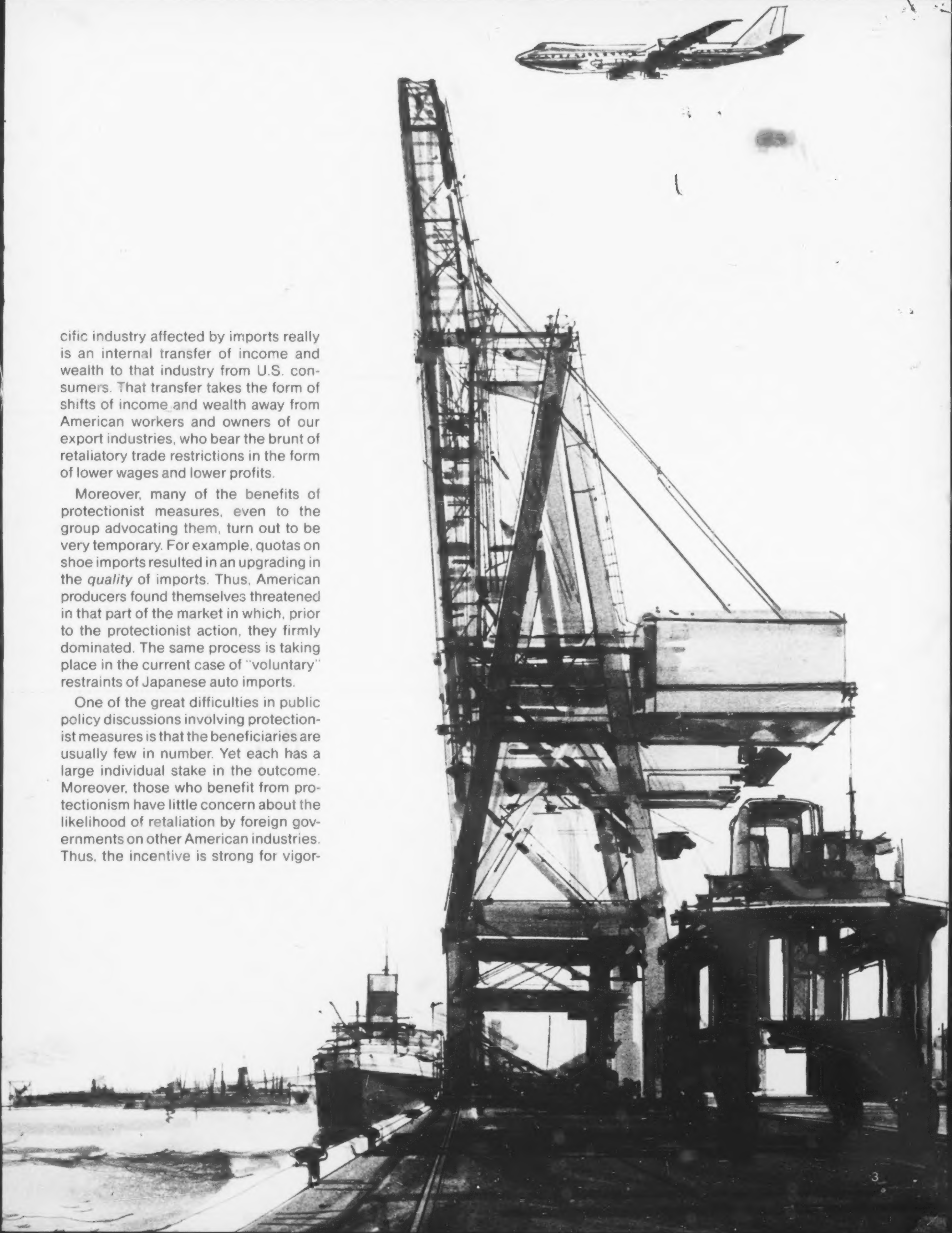
Forced Transfers, Made in Washington

What is less apparent, however, is that any form of trade restraint to help a spe-

cific industry affected by imports really is an internal transfer of income and wealth to that industry from U.S. consumers. That transfer takes the form of shifts of income and wealth away from American workers and owners of our export industries, who bear the brunt of retaliatory trade restrictions in the form of lower wages and lower profits.

Moreover, many of the benefits of protectionist measures, even to the group advocating them, turn out to be very temporary. For example, quotas on shoe imports resulted in an upgrading in the *quality* of imports. Thus, American producers found themselves threatened in that part of the market in which, prior to the protectionist action, they firmly dominated. The same process is taking place in the current case of "voluntary" restraints of Japanese auto imports.

One of the great difficulties in public policy discussions involving protectionist measures is that the beneficiaries are usually few in number. Yet each has a large individual stake in the outcome. Moreover, those who benefit from protectionism have little concern about the likelihood of retaliation by foreign governments on other American industries. Thus, the incentive is strong for vigor-



ous and concentrated political activity designed to erect special-interest trade barriers.

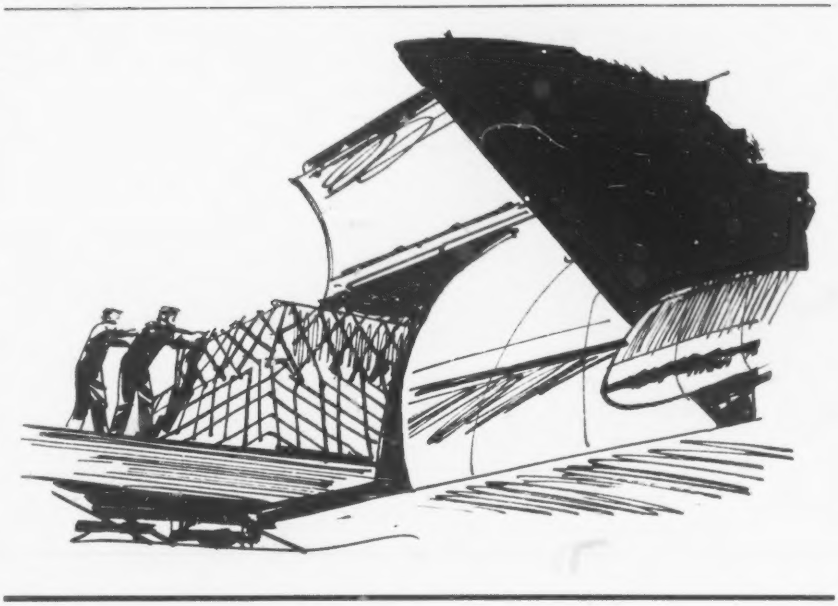
In addition, pleas for protectionism reflect the ability of relatively small but influential groups to convince legislatures to adopt policies that benefit them, albeit at the expense of citizens at large. The balance of power is extremely uneven, given the limited knowledge that consumers currently have about these matters.

Those who benefit from exports and from the greater supply of goods and services are generally not even aware of the process by which they benefit. Although the benefits of open trade may far exceed the costs, those benefits—such as lower prices to consumers—are widely diffused among 50 states and 225 million residents. Any single consumer's stake in the outcome is quite small. The individual consumer almost surely is not aware of why the price of a given item is going down—or not rising. Consequently, resistance at the grassroots level to protectionist measures often is considerably less than pressures for their adoption.

Nevertheless, the consumer savings from freer trade exceed any sensible adjustment programs instituted for those who are initially hurt by the change.

Scholarly studies typically show that the total benefits of freer trade far exceed the costs. These gains from trade include savings to consumers, gains from moving resources out of inefficient sectors, stimulus to investment, and increased economies of scale. One study concluded that the benefits of tariff reductions are approximately 80 times as large as the costs of labor adjustments. Those costs are primarily the unemployment resulting from increased imports.

High ratios of economic benefits of trade liberalization to labor adjustment costs have also been estimated for other nations, ranging from 49 to 1 in Japan to 96 to 1 in the European Economic Community. Both aggregate and specific comparisons show that the benefits of protectionist measures are far less than the total costs imposed on society.



Resenting Their Barriers, Excusing Ours

Despite the lip service that is paid so often to the virtues of free trade, there is great danger that the United States may be taking the lead in the current rush toward protectionism. Public policy debates are increasingly dominated by one-sided, self-serving views of international trade. Everyone wants open markets and free trade overseas. We all know how urgent it is to eliminate *their* barriers to our exports. But *our* barriers in the United States to their exports do not generate much interest over here.

The problem can be explained with a simple example—Country A and Country B. Country B has a large export surplus with Country A. Country A has great difficulty getting its exports into Country B. Sounds familiar? Of course, Country B (large trade surplus) is Japan and Country A (large trade deficit) is the United States.

But that is not the end of the story. When we take another look, we find that Country B (large trade surplus) is also the United States and Country A (large trade deficit) Western Europe. After all, we have enjoyed a trade surplus with the Common Market over the last decade, about as large as Japan's surplus with us. It would help to clear the air in international trade discussions if the United States were to acknowledge that we do not have clean hands.

Let us remind ourselves of our many departures from free trade. For example, "Buy American" statutes give preference to domestic producers in government procurement. As much as a 50 percent differential is paid for military goods produced at home. In addition, the Surface Transportation Assistance Act requires that, for most purchases over $500,000, American materials and products be used for that mass transit subsidy program. Also, American flag vessels must be used to transport at least 50 percent of the gross tonnage of all commodities financed with U.S. foreign aid funds.

And then there are the Buy American laws of the various states. New York requires state agencies to buy American steel. New Jersey requires that all state cars must be domestically produced. In addition, numerous states and municipal authorities require use of American materials in utilities, whether privately owned or publicly owned.

Block That Mushroom

Let us not forget the Jones Act. That piece of special-interest legislation prohibits foreign ships from engaging in commerce between American ports. This law, of course, effectively bars all competition in U.S. domestic marine transport. The perverse effects of such cabotage laws are greater than might be expected. For example, at times Canadian lumber transported in Japanese flag vessels has undersold domestic timber from Oregon in the lucrative Southern California markets. In such cases, both the American merchant marine and the American timber industry suffer damage.

Many other statutes limit imports of products such as sugar, beef, dairy produce, and mandarin oranges. Under the Meat Import Act, the President has authority to impose import quotas on beef if imports reach a certain trigger level. In practice, the U.S. has "encouraged" foreign exporters to restrain their sales "voluntarily" to avoid the imposition of formal quotas.

Although our average tariff rates are low, high tariffs are levied on selective items. Tariffs on textiles average 20 percent. Duties on fruit juices are over 27 percent, and the rate on ceramic products is over 14 percent. All this is in addition to numerous nontariff barriers, often of a regulatory nature and imposed by federal, state, county, and municipal governments.

Despite this nation's overall free-trade posture, protection against imports into the United States now covers such basic industries as automobiles, steel, and textiles. Pleas for further trade restrictions extend to such esoteric sectors as mushrooms, ceramic tableware, and mechanics' shop towels. It is not a question of merely accepting the existing array of protection. The challenge is to deal with the rising pressures for further restriction of world trade.

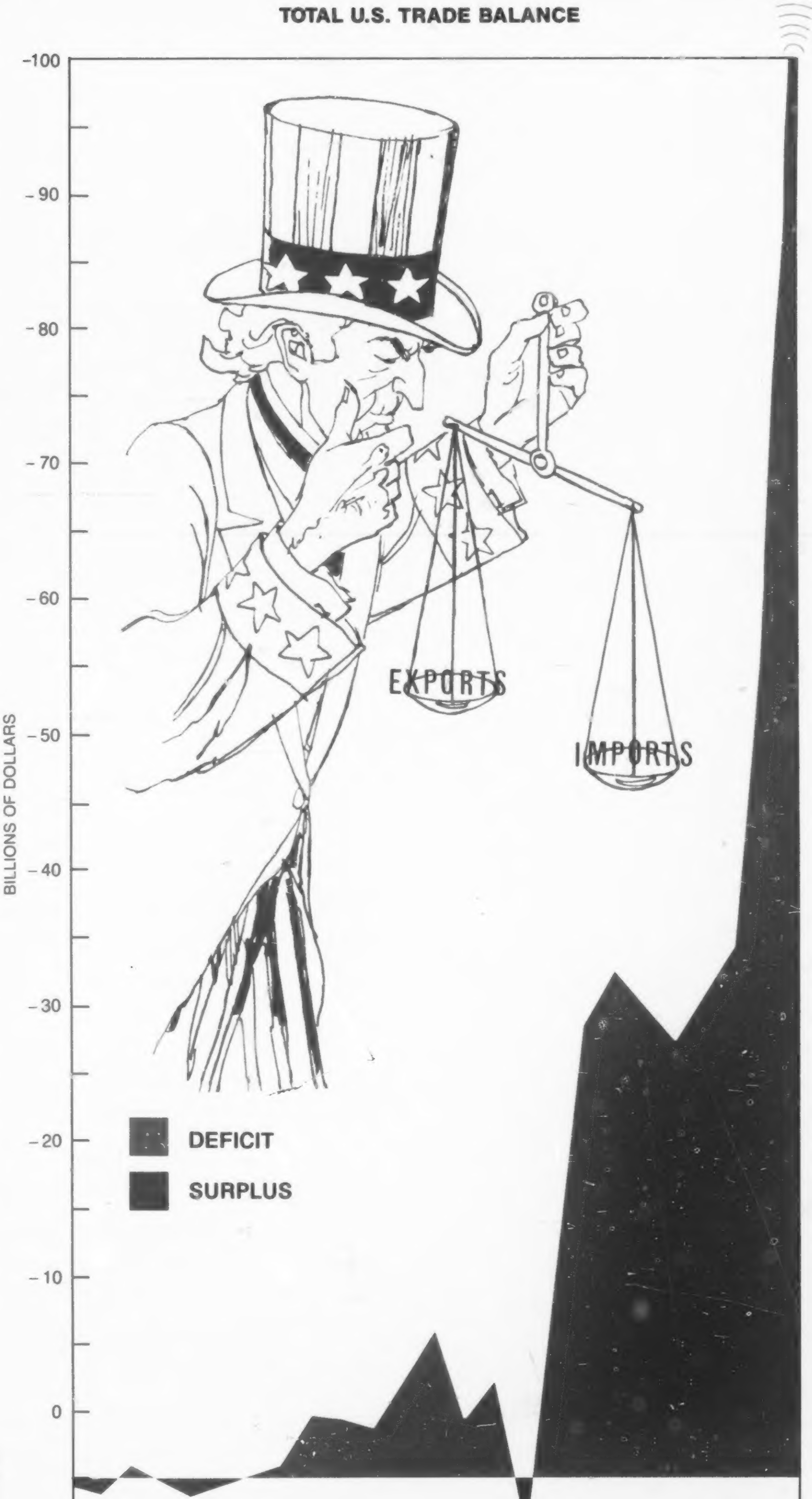
Protectionist measures are a two-edged sword. They may reduce imports from abroad. The United States was "successful" in getting the Common Market to restrict its exports of steel to this country. But let us examine the results. First of all, the domestic automobile industry, a major purchaser of steel, bears the burden of higher costs, which in turn make it less competitive. In addition, lower imports mean fewer dollars abroad to buy American exports. All this generates pressures for more protection.

Furthermore, protection often generates retaliatory measures, which hit the unprotected sectors of the economy. For example, in January 1983, the U.S. government imposed import quotas on textiles and apparel from China. It is interesting to note that this action followed the breakdown of negotiations for the extension of a "voluntary" quota that expired at the end of 1982. The Chinese government retaliated by cancelling new contracts for the importation of U.S. cotton, synthetic fiber, and soybeans. China's retaliation to our trade restrictions hit a very different sector of the economy and had a much broader regional effect than the beneficiaries of the protectionist action.

How We Impede Exports

Moreover, we must acknowledge that in the United States many laws and regulations limit our exports. In many ways - and often without considering the effects —we have enacted laws and promulgated regulations that prohibit U.S. exports or make it more difficult for American companies to export.

For example, the Trans-Alaskan Pipe-



The chart shows the alarming increase in the U.S. trade deficit, a trend whose reversal is vital to the U.S. economy. But in developing trade improvement strategy, says Dr. Weidenbaum, the U.S. must eschew protectionism and continue to promote free trade.

line Authorization Act prohibits the export of oil from North Slope fields.

A provision added to an appropriations act for the Interior Department bans timber exports from federal lands west of the 100th meridian.

The Export Administration Act provides for controls on exports of goods and technology to protect national security. That sounds fine. But, in practice, the law mandates controls over a great variety of products, including domestically produced crude oil, refined petroleum products, unprocessed red cedar and, my favorite, horses exported by sea.

In 1980, the act was employed to embargo grain exports to the Soviet Union. It was invoked again in 1982 to carry out the ban against U.S. firms participating in the construction of the natural-gas pipeline between the U.S.S.R. and Western Europe.

Studies of how export controls actually work conclude that the more sensitive applications for approval under the Export Administration Act get tied up in a bureaucratic morass. There is a good deal of evidence that the licensing system has been a powerful disincentive to exporting.

Exports controls do more than limit U.S. international trade for the time they are imposed. Such restrictions call into question the long-term reliability of the United States as a future supplier of products to other countries. Those nations are likely to develop alternative sources.

A clear example is soybeans—hardly a product that could be considered a strategic item. The main effect of the U.S. embargo of soybean exports in 1974 was to induce Japan to turn to other producing countries, particularly Brazil. Japan proceeded to invest huge amounts in that country to develop alternatives to U.S. production, thus effectively and permanently reducing our share of the world soybean market.

The United States also conducts a great variety of domestic regulatory activities that impose costly burdens on American manufacturers. In many cases, foreign producers are not subject to similar burdens. In addition, the federal government has imposed special burdens on companies involved in foreign trade. The Foreign Corrupt Practices Act requires strict recordkeeping standards to monitor the anti-bribery sections of the statute. It is difficult to discuss that law without being criticized for callousness on ethical matters. However, the sad fact is that this international trade statute has established a regulatory regime that displays the same cavalier attitude toward the burdens it imposes on American business as do so many domestic-oriented regulations.

A former Chairman of the Securities and Exchange Commission, the agency administering the act, has stated, "The anxieties created by the Foreign Corrupt Practices Act—among men and women of utmost good faith—have been, in my experience, without equal." The language of the act is so sweeping and ambiguous that American firms turn down foreign business when they merely suspect that they could be charged with actions that technically might be classified as bribery, although in practice these payments may be closer to paying protection money to the Mafia. The General Accounting Office found, in a survey of 250 American companies, that 30 percent of the respondents engaged in foreign trade had lost business as a result of the Foreign Corrupt Practices Act.

In addition to the effects of trade policies themselves, the strong foreign exchange value of the dollar makes it difficult for American companies to compete in world markets. Many factors influence the strength of a nation's currency. But our extraordinarily high real interest rates are very important. In turn, the large budget deficits are a key influence on those high rates—and we cannot blame the deficits on "foreign devils." They have a made-in-America label.

Foreign Threats to International Trade

By no means is the United States the only nation with trade barriers. Every nation has them. The European Community levies duties on wheat, barley, oats, sorghum, rye and rice. Italy bans foreign-produced television commercials. Japan finds all sorts of reasons for keeping out baseball bats.

Japan commands our attention in this regard and some special consideration of this important trading nation is appropriate. Viewed from a broad, historical perspective, Japan, of all the major developed nations, has most recently made the transition from a developing country to a mature, industrialized economy. However, it has only begun to change its policies and customs to reflect that fundamental shift. Yet, looking at the decade of the 1980s, it is clear that Japan now has a key stake in the health of the world trading system. It has benefitted most substantially from the greater openness of the economies of the rest of the world. Without that liberal environment, I doubt that its export-led growth would have occurred. Surely, steps to open its markets more widely to foreign trade and investment are long overdue.

The sooner that Japan succeeds in adjusting its trade posture to current economic realities worldwide, the sooner will its trade relations with more open economies move to a more amicable basis. Under the circumstances, I am pleased to note the recent steps that the Government of Japan has taken to reduce its tariffs and to soften administrative barriers to imports. As Foreign Minister Abe (the former head of MITI) has said, "I myself do not feel that the requests from America regarding market liberalization are pressures. These are

> **"Despite the lip service that is paid so often to the virtues of free trade, there is great danger that the United States may be taking the lead in the current rush toward protectionism. Public policy debates are increasingly dominated by one-sided, self-serving views of international trade."**

things that Japan should be doing anyway." No doubt, from the viewpoint of Japan, the recent moves to liberalize trade came very rapidly. To outside observers, however, it is more a matter of making up for a very late start.

Threats to free trade are multiplying, with a growing array of industrial sectors obtaining "protection." The concerns of these producers and the public will be better served by responding to the far underlying problems that generate pressures for protectionism. This leads me to the policy implications of these remarks.

Four Positive Strategies

As I see it, the United States should simultaneously pursue four positive and mutually supportive approaches in combatting protectionism and promoting free trade. First and most fundamental is carrying out domestic economic policies that expand production and incomes while holding down inflation. This, of course, is a plea for tax cuts, reduction in government spending, and regulatory relief. A healthy economy nips the protectionist bud at its source.

The second approach to promoting free trade is to achieve greater stability and balance in macroeconomic polices. The shift in 1981 to tight monetary policy and expansive fiscal policy in the United States contributed substantially to high interest rates and a rise in the value of the dollar coupled with recession. If we are not careful, we will now see an easy-money policy—coupled with out-sized budget deficits—lead to another inflationary spiral. That would further reduce the competitiveness of U.S. products in world markets.

The third approach to promoting free trade is to limit any governmental "trade adjustment assistance"—which seems to be a politically necessary part of any comprehensive trade policy—to temporary aid in shifting labor and capital from industries hard hit by imports to more competitive activities. All too often, the government aid merely maintains an inefficient and uncompetitive industrial structure. That, in turn, adversely affects our competitiveness in world markets and, predictably, generates further pressure for additional protectionist measures. The result is to lower domestic employment, which, in turn, generates additional pressures for government interference. That is an example of a more general principle: government intervention begets more government intervention.

In a healthy and dynamic economy we must expect that some industries and regions will grow more rapidly than others and that some sectors will experience difficulty in maintaining their position and may even decline. We must rely primarily on market forces, and not on government bailouts, to make the appropriate adjustments.

In a related aspect, the developing nations need adequate access to the markets of the more developed countries if they are going to be able to service the massive indebtedness that they have incurred. However painful, the developed nations must adjust their economic structures to this reality.

The fourth approach to promoting free trade is to acknowledge the positive role of multinational corporations in the world economy. Multinationals adapt to change more readily and are less likely to plead for protection than other companies. They also are the private-sector alternative to foreign aid and other types of government intervention. This, of course, explains why so-called transnational enterprises are not universally popular, especially among the bureaucracies of international governmental organizations.

Ending the Monday-Wednesday Charade

The serious question facing us is how to encourage our trading partners to open their markets without using mechanisms that harm the international trading system or start a spiral of retaliation. The current interest in what is now called "reciprocity" raises such dangers. Yet, until markets are open more fully, these pressures will continue.

But the current economic problems that face most countries will not be solved by responding to the parochial concerns of steel producers, citrus growers, and automobile makers. Nor should international economic relations be dominated by short-term protectionist pressures from the producers of edible seaweeds, casein, and manhole covers, to name some recent candidates for protection.

The question is frequently asked, "Other nations do not have a policy of freer trade, so why should we?" But rather than talking in absolutes, the more appropriate question to ask is, "Are the trade policies of other nations more open today than they would be without the continued pressure of agreed international 'rules of the game'—rules developed under the persistent and patient influence of the United States?"

The answer is a resounding "yes." Trade policy, here and elsewhere, is far more open today as a result of our efforts and of our example of an open domestic market. Our federal system, after all, was the original common market.

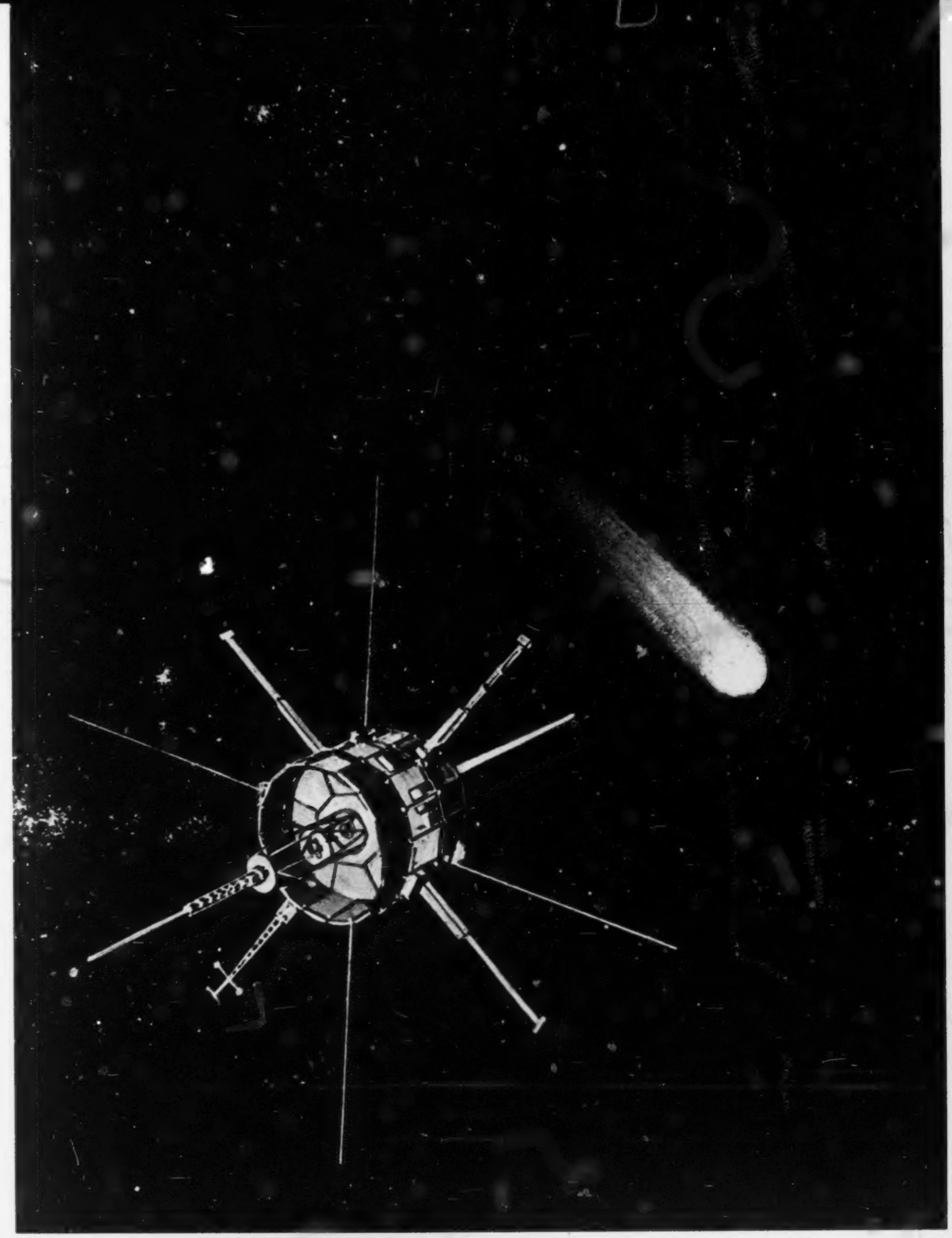
Is the U.S. better off with lower trade barriers? Again, the response is positive. The goods we import are cheaper than domestic substitutes. Our 225 million consumers have more choice. The markets for our exports are less restricted than they otherwise would be. Thus, despite the numerous real obstacles, many American companies have experienced significant success in penetrating foreign markets. Coca Cola is the largest-selling soft drink in Japan, Schick is the number one in their razor market, and Nestle commands 70 percent of Japan's instant coffee market.

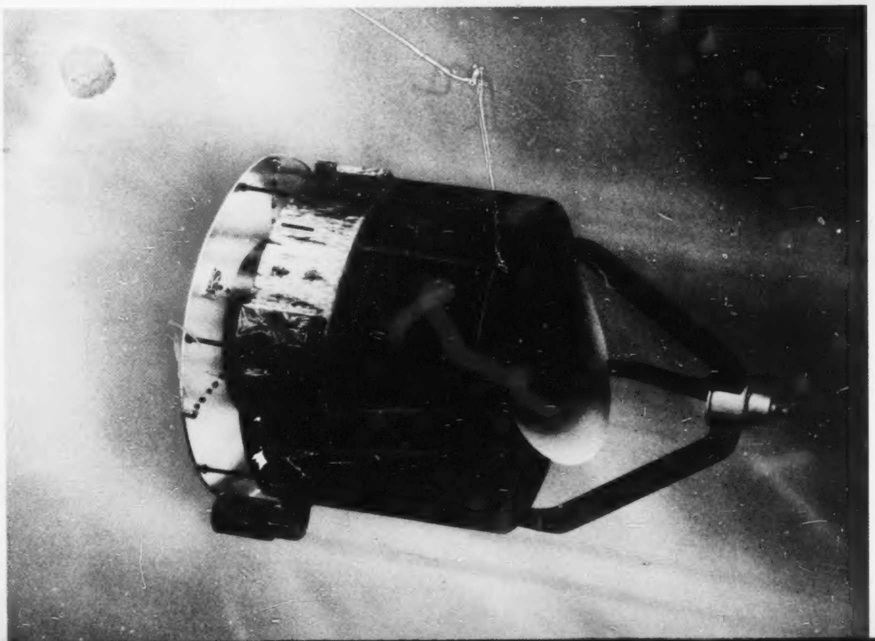
The credibility of this country's commitment to open and freer trade is not enhanced by companies sending their lawyers to Washington on Monday to seek the removal of import barriers overseas, and then turning around on Wednesday to send the same attorneys back to Washington to *advocate* import restrictions on the products of their foreign competitors.

International trade policy will not remain static. The choice is between a further drift to protectionism and a joint effort to remove trade barriers.

The longer we wait to move decisively to freer world trade, the more obstacles will be in place and the more difficult it will be to remove them. The best time to move to free trade is now.

NASA's *International Cometary Explorer* is already en route to what will, if additional course corrections are successful, be the first close encounter with a comet; it will fly directly through the tail of Comet Giacobini-Zinner in September 1985.

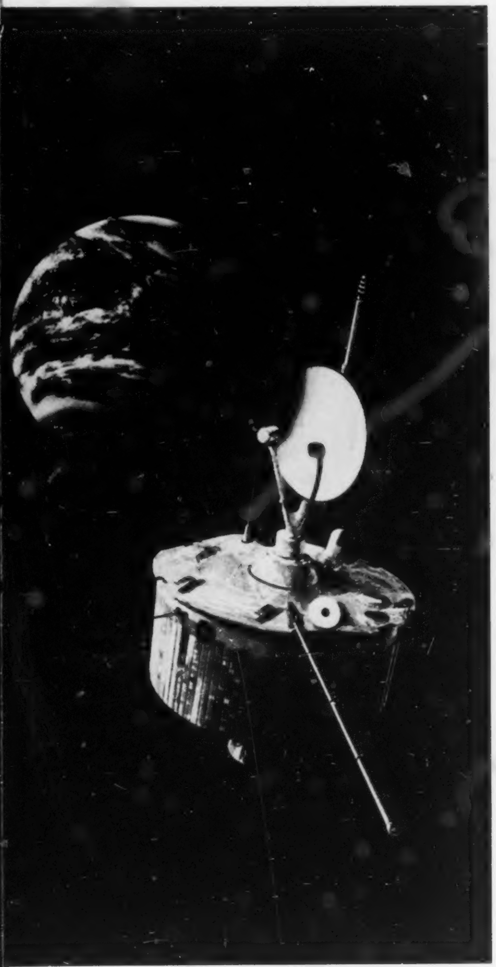




An artist's impression of the European Space Agency's *Giotto* spacecraft speeding toward a March 1986 encounter with Comet Halley. *Giotto* will make an eight-month journey to the rendezvous, but its data-gathering equipment will operate for only a few hours prior to and during the encounter; it may not survive its passage—at 40 miles a second—through the comet's tail. The artist depicts Halley in nucleus form, without the multimillion-mile tail, which is not present most of the time; it builds up only when Halley approaches the Sun once every 76 years.

CLOSE ENCOUNTER WITH A COMET

BY JAMES J. HAGGERTY



NASA's *Pioneer Venus Orbiter,* which has been circling Venus for several years, will be the only spacecraft in position to observe Comet Halley at perihelion, the point at which the comet comes closest to the Sun. The close encounters with Halley by other spacecraft will come after perihelion.

A basic aim of science is a complete understanding of how the solar system began and how it evolved, a quest that has practical as well as scientific implications. Such knowledge is an essential underpinning to development of a comprehensive encyclopedia of the past and present processes affecting humanity's environment, a body of information that could in time open the door to management of the complex forces that govern Planet Earth for sweeping benefit to mankind.

Closeup and telescopic studies of the planets have provided much important evolutionary data through the process of "comparative planetology"—relating phenomena on one planet to conditions on another. But the planets, particularly the inner planets, have changed considerably since the solar system was formed some four and a half billion years ago. Scientists need a way of looking back to the beginning; they need to observe celestial sources that still exist more or less as they did in the days of the solar system's genesis.

That is why comets have become priority targets of scientific research. Residing in distant space in what one study calls "a frozen state of suspended animation," comets are thought to have originated within the solar system and they are believed to contain materials relatively unchanged since the formative epoch; thus they offer immensely valuable clues to the earliest physical and chemical makeup of the solar system.

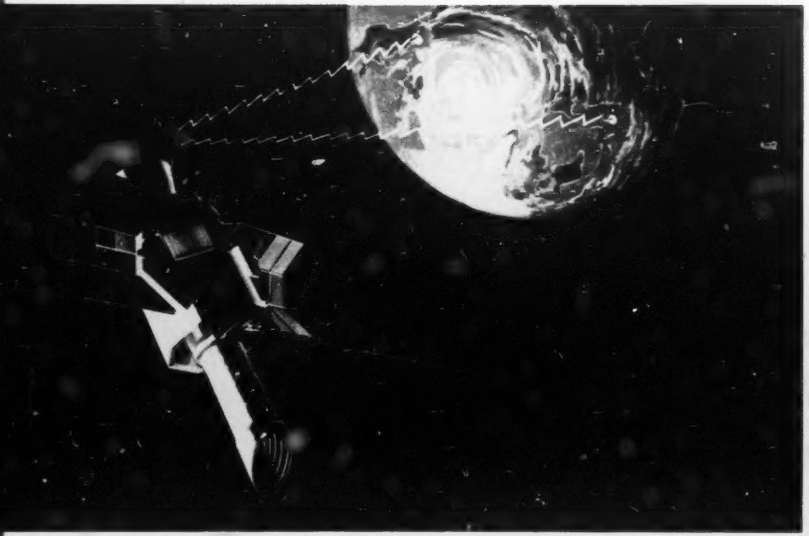
Comets are "small bodies," largely invisible to Earth-based telescopes except when they journey to Earth's vicinity—and very few of the estimated trillions of comets ever do so. Therefore, cometary knowledge is slim. Now, however, space technology has advanced to the point where spacecraft with imaging equipment can be maneuvered to close encounters with comets or, equipped with sensitive instruments, can make important observations from positions millions of miles distant. There is now under way a major international effort in space-based cometary study, one that will focus on the most famous small body—Comet Halley—as it makes its once-every-76-years close approach to the Sun.

In December of this year, the Soviet Union will launch a pair of deep space probes, the first of five spacecraft targeted for close encounters with Comet Halley in March 1986. Next year Japan will launch another pair and in July 1985 the European Space Agency will send its *Giotto* spacecraft into Halley-bound trajectory.

There will be no U.S. spacecraft in the flyby fleet. Such a mission was once planned, but it was axed by the budget wardens, a fact that has caused a lot of justifiable hand-wringing among the U.S. scientific community. Since the spectacular Halley will generate worldwide interest, many scientists feel that the absence of an American probe in the close encounter flotilla will be a prestigial tragedy.

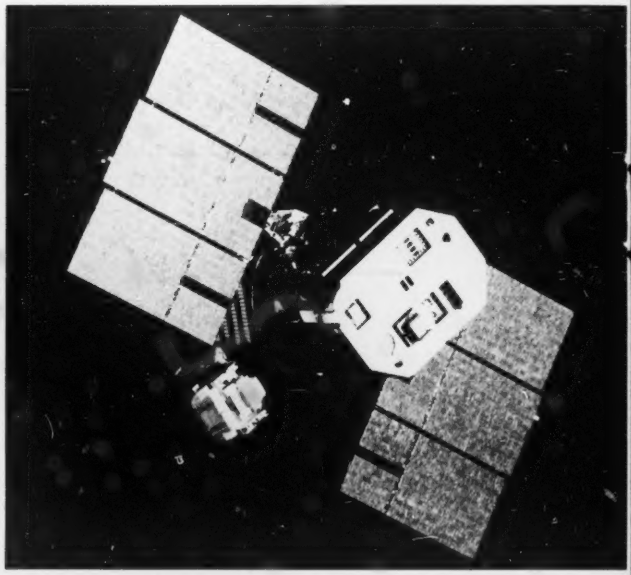
But there is a bright side. Having been denied the opportunity to rendezvous with Halley, NASA scientists have been quietly developing other, lower-cost options for comet research. They have come up with several. They have figured out ways for jockeying already-orbiting spacecraft into positions for comet-watching. They are taking advantage of the Shuttle Orbiter's capability as a comet observation post. NASA also has responsibility for Earth-based data collection activities in connection with Halley—coordinating the flow of information from worldwide sources.

In short, far from being left out of the Halley look, NASA may well be the most active of all the groups involved. Not only that, but the first close encounter with a comet will—if all goes well—be made by a NASA spacecraft six months before the Soviet, Japanese and ESA probes meet with Halley.



NASA's *International Ultraviolet Explorer* will observe Halley remotely from its position in geosynchronous Earth orbit. Its imaging telescope can provide important data to complement the information acquired by the close encounter fleet.

NASA's *Solar Maximum Observatory,* shown being repaired in orbit earlier this year, will train its imaging equipment on Comet Halley from its position in low Earth orbit.



An understanding of the kinds of information the comet-observing spacecraft will seek is best prefaced bya brief summary of what scientists know—or presume—about comets, and what they would like to know.

A "cloud" of comets—know as the Oort Cloud—surrounds the solar system at a distance about halfway to the nearest star. Occasionally, a comet affected by star gravity is pulled out of its normal orbit within the cloud and thrust into a trajectory that takes it toward the Sun. Sometimes the Sun's gravity captures a comet, so that it goes into solar system orbit and—like Halley—returns again and again.

Comets are believed to be "dirty snowballs" composed of dust, rock and water ice. In deep space, a comet does not have the characteristic tail; the tail, millions of miles long, develops when the comet approaches the Sun and solar heat vaporizes the comet's ice, causing it to emit large quantities of gas and dust.

Scientists want to study a comet's passage around the Sun to get information on the changes that occur in the tail, the nucleus (main body) and the coma, a hazy, luminous region surrounding the nucleus. They are interested in the size, shape, mass, thermal properties and rotation of the nucleus; the physical and chemical composition of the gas/dust outflow; and how the coma is affected by interaction with the solar wind, a million-mile-an-hour stream of electrified gas coursing outward from the Sun in all directions. This information could provide answers to many scientifically-important questions, for example, whether comets are really unchanged from the time of the solar system's formation or whether they have undergone some form of evolution; whether they are remnant "building blocks" from which planets were formed; whether comets, colliding with Earth billions of years ago, seeded our planet with organic molecules and thus played a part in the development of life.

Comet-observing spacecraft will carry extensive data acquisition equipment, some of it instruments long in use, some of it new. Imaging systems of the type employed in closeup planetary investigations will be a primary source of information; their sensors will acquire data that can be computer-converted to pictures—not pictures in the ordinary sense but specialized views that show features not visible to cameras, such as temperature or pressure distribution, or the type and density of cometary materials. Conventional color cameras will supply complementary photographic detail. Spectrometers will provide clues to a comet's makeup by analyzing the various bands of visible and invisible light emitted. Some spacecraft will have dust particle impact detectors, optical probes for measuring the density of gas and dust emissions, devices for determining a comet's magnetic field and sensors for measuring the velocity, characteristics and effect of the solar wind.

The first close encounter with a comet will take place next year. The target will not be Halley but another comet—known as Giacobini-Zinner—making an earlier approach to the Sun. The probe will be NASA's *International Cometary Explorer (ICE),* a veteran spacecraft launched in 1978; then known as ISEE-3, for *International Sun/Earth Explorer,* its assignment was study of solar phenomena, in particular the interaction between the solar wind and Earth. After four years of successful operation, ISEE-3 was given a new job and its new name. Controllers at Goddard Space Flight Center, which designed and built the spacecraft, in cooperation with ESA, ingeniously figured out a way to fire its propulsion system to nudge it out of its Sun-monitoring orbit into a new path that will take it to a September 1985 rendezvous with Comet Giacobini-Zinner. ICE will fly directly through the comet's tail; although it has no imaging equipment, its instruments can provide valuable data on temperatures, gases, particles and magnetic forces within the tail. If ICE survives the encounter, it will be in a position to provide solar wind data when Comet Halley approaches the Sun.

The Halley close encounter spacecraft

A new Shuttle-based observatory called *Astro* will make its flight debut coincident with Halley's approach to the Sun. *Astro* will acquire Halley pictures with three imaging telescopes and a pair of conventional cameras.

will fly through the comet's tail, at various distances from the nucleus, about a month after perihelion, the point at which the comet comes closest to the Sun. First to rendezvous will be the Soviet *Vega 1*, targeted to pass within about 6,000 miles on March 6, 1986. Its companion *Vega 2* will encounter Halley at less than 2,000 miles on March 9. The Soviet spacecraft carry two imaging spectrometers and a number of optical instruments, including two television cameras. En route to Halley, the Soviet "interplanetary station" will fly by Venus and release a "landing craft," according to the Soviet Novosti Press Agency.

The Japanese probe *Planet A*, equipped with a solar wind measurement instrument and a system for imaging in invisible ultraviolet leght, will fly past Halley on March 7 some 125,000 miles from the nucleus—close enough in cosmic terms to qualify as a close encounter. Its teammate, designated *MS-T5*, will make a pass about 6,000 miles from the nucleus on the following day.

The European Space Agency's *Giotto* will venture closest to the Halley nucleus, as close as 300 miles, depending on the success of several en route course corrections. Built by British Aerospace Dynamics, *Giotto* is the most comprehensively instrumented of the close encounter fleet; it will carry an imaging system, three spectrometers, a magnetometer, an optical probe and other equipment to perform a total of 10 experiments.

What will the U.S. be doing while other nations' spacecraft are taking a close look at Halley? Quite a bit.

For one thing, the U.S. has a piece of the *Giotto* action; American scientists will be co-investigators on nine of the 10 experiments that make up Giotto's payload. In addition to ICE and a series of Halley-watching sounding rockets, NASA plans to put to work three already-orbiting spacecraft, which will make specialized observations from a distance rather than up close:

- The *International Ultraviolet Explorer (IUE)*, which has been operating in space since 1978, has a system for studying ultraviolet light emitted by celestial objects; measurement of the light's wavelength and intensity offers a means of determining which elements are present in a substance, such as Halley's tail. In 1982, IUE provided data for ultraviolet images of the newly-discovered Comet Austin.
- The *Solar Maximum Observatory*, the subject of history's first on-orbit repair job earlier this year, will use a coronagraph—originally designed to make images of solar flares—to take pictures of Halley. *Solar Max* also has an ultraviolet spectrometer for examining Halley's nucleus.
- The Hughes Aircraft-built *Pioneer Venus Orbiter*, which has been circling Venus since 1978, will be the only spacecraft in a position to observe the comet at perihelion, when it is most spectacular; that's because Venus—and its man-made moon—will be relatively close to Halley at perihelion, while Earth—and Earth-orbiting spacecraft—will be on the opposite side of the Sun. This allows the U.S. to make a unique and important contribution to the Halley look. NASA mission controllers plan to tilt *Pioneer* to point directly at the passing comet, enabling the spacecraft's ultraviolet spectrometer to observe the gases and dust emanating from Halley. Last April, NASA conducted a dress rehearsal, tilting *Pioneer* to study Comet Encke.

NASA will also have in orbit a new Shuttleborne observatory called *Astro*, a system of three imaging telescopes designed to fly on a number of Shuttle missions to study stars and galaxies in ultraviolet light. The first seven-day mission—*Astro 1*—has been scheduled for March 1986 to take advantage of the Halley opportunity. For that mission, the system will include a pair of visible-light cameras for Halley photography.

In addition to all that flight activity, NASA will play a lead role in coordinating the flow of Halley information. The NASA-sponsored International Halley Watch (IHW), composed of scientists all over the world, will make observations, analyze data and monitor the operation of ground-based instrument and instruments aboard the international fleet of spacecraft, sounding rockets, aircraft and balloons. All this information will be channeled to a central Halley archive. Co-leaders of the IHW are NASA's Jet Propulsion Laboratory and West Germany's University of Erlangen-Nurnberg.

The current, Halley-focused research effort will not provide all the answers scientists seek, but it will create a foundation for more advanced research. NASA is planning a program—not yet approved for hardware development—of more extensive study of comets and closeup investigations of asteroids. Although some asteroids have undergone evolutionary changes, many are believed to be preserved remnants of the era of solar system formation. NASA plans development of an advanced spacecraft that could rendezvous with comets and asteroids and "fly formation" with them for months, to acquire more voluminous data than can be collected during the brief Halley fly-bys. This program includes a plan to return to Earth samples of cometary material for detailed laboratory analysis. Although no firm timetable has been set, this program could get under way in the next decade.

TECHNOLOGY TRANSFER and NATIONAL SECURITY

BY DR. ROLAND W. SCHMITT
Senior Vice President
Corporate Research and Development
General Electric Company

The United States must remain technologically superior to any adversary in weapons and defense. We are waging a a technological battle with the Soviet Union. Too often, we find that we have superior technology, but they have equal or superior weapons. They are good at extracting technology from us and good at deploying it rapidly in weapons, while we are good at generating new technology but often slow at deploying it in weapons.

To correct this imbalance, we must do two things: prevent them from getting our technology and speed up our own deployment of it. But that is like saying that to win in sports you must score a lot of points and prevent your opponent from scoring. There is more to it.

It makes a big difference, for example, whether you are playing football or basketball. The balance between offense and defense is vastly different in the two. In basketball, unlike football, you cannot indefinitely strengthen the defense without weakening the offense. So too, in winning the technological battle with the Soviets, an obsession with a defense strategy—with preventing leakage of our technology—will cripple our offense, our ability to remain the leader in generating new technology.

The balance between a leadership strategy and a protective strategy—between offense and defense, if you will—will determine the outcome of our contest with the Soviets. A fundamental change in that balance is being proposed today. In the past, the essence of our strategy consisted of putting a fence of technology export restrictions around the Soviet Union and Eastern Bloc countries to keep technology out. The proposed new strategy would put the fence around the United States to try to keep technology in.

Such a change in strategy has vast implications for both our national security and our international economic competitiveness. We need to look very closely at the full effects of such a change to see what the core issues relating technology and national security are. There are four core issues where differing views still exist. First, dual use—determining the extent and implications of the dual use of the same technology in both military and civilian applications. Second, military criticality—determining just how critical a technology is to improving military capability. Third, foreign availability—determining whether a technology is available from a foreign country and, if so, what we can do about the transfer of that technology to the Soviet Union. And fourth, effective transfer—determining which technology transfer mechanisms are truly effective.

The dual use issue is as old as technology itself—as old as the swords and spears that the prophet Isaiah proposed pounding into plowshares and pruning hooks; as old as the mirrors that Archimedes used to edify the people of Syracuse and then allegedly turned on the Roman fleet; as old as the telescope that a couple of lens grinders in Holland invented as a means to spy on their enemies, but that turned, in the hands of Galileo, into something very different.

It wasn't so long after Galileo's day that a separation began to emerge between military telescopes and the ones used by the astronomers. Generally speaking, the breadth of dual use tends to diminish as you go from fundamental science toward final application.

Consider very large scale integration, for example. At the fundamental science end, the things one has to learn are clearly generic to all possible applications. Dual use is complete. The same goes for the next stage; engineering principles are clearly common to military and civilian technologies. Dual use persists to a large extent in the fabrication processes.

By the time you reach the application stage, the chips used in military systems are likely to be distinct from the ones used in commercial products. Popular press reports to the contrary, it's unlikely that a chip taken from a video game would really serve as the critical part in a missile guidance system.

In the final stages of military deployment of technology, the Soviets have in many cases been faster than us, as I suggested earlier. At times recently they have appeared to be also getting better further upstream—further in the direction of engineering principles and fundamental science. This has given rise to the demand for more controls upstream.

I believe that these demands are misguided. Restrictions on those fundamental areas would cost us more in leadership than they would gain us in protection. The work at the fundamental end of the process provides leadership research, educational experience for students, and an invaluable forum for access to world science and technology.

After deciding whether a technology is dual use, we next have to ask about its military criticality. The issue here centers on exactly what we mean by that term. We must avoid confusing it with military utility. A militarily critical technology gives a nation's armed forces a new capability that it did not posses before—one that is capable of changing the military balance in some area of national defense. A militarily useful technology only makes an incremental improvement, either by providing incrementally better performance or by enabling a nation to produce more of the weapons it already possesses for less money or in less time.

The Department of Defense has compiled a 700-page "Militarily Critical Technologies List." Its name suggests that this distinction has been taken into account. But in fact, the list in its present form is a combination of militarily critical and militarily *useful* technologies.

As I see it, that list should have two

purposes. The first, which the present list fulfills admirably, is to alert the Department of Commerce to sensitive areas for Department of Defense reviews of proposed licenses for export of technical data to Communist countries.

But the list has another purpose: the monitoring and control of technology exports to non-Communist nations. For that purpose, the present list is far too inclusive. In its present form it would put severe restrictions on the transfer of many militarily useful but not militarily critical technologies to those nations. This would hurt us economically, and it would hurt our ability to generate leadership technology by taking advantage of the best foreign knowledge. The harm caused by these two impacts, in my view, outweighs the benefits to us of restricting the flow of militarily useful technology to non-Communist nations.

So we need a second version of the Militarily Critical Technologies List—one listing only truly militarily critical technologies and aimed at technical exchanges with non-Communist countries. If a technology is found to be militarily useful only, then its export to non-Communist nations should not be subjected to the strictest controls, and we should rely on our ability to attain leadership as the means of keeping our edge.

Suppose now that we have found a technology that is dual use, has reached the engineering prototype state, and has been determined to be militarily critical—all indicating that we should impose strong controls. The next issue is foreign availability—can it be obtained outside the United States?

There are really two questions here: what does foreign availability mean and what impact does it have on controllability? It is possible to define foreign availability so narrowly that you find that nothing is available in foreign countries. But you have to go beyond carbon-copy availability and consider functional equivalence as well; can the technology available overseas do the same job as the domestically available one? Two computer memory chips might be deemed functionally equivalent if they both pack the same number of bits onto the same area of silicon, with the same access time, even though they achieve this by totally different processes and design rules. The real question is whether the military function can be accomplished in an essentially equivalent way by a technology available from a non-U.S. source.

This concept of functional equivalence has been written into recent proposals for updating the Export Administration Act. I believe it belongs in the act.

The other part of this issue is, who has it? If another friendly nation already has a technology capability, we can gain more by including them within the fence than by shutting them out. Therefore, I recommend that we permit general licenses on the export to friendly nations with whom we have a bilateral agreement on technology that is available to them anyway, and that we seek to use those agreements to strengthen controls—to keep that technology from going beyond those countries to the Communist bloc.

Suppose a technology meets all three criteria discussed so far—it is dual use, it is militarily critical, and it is not available overseas. Then there is one more issue to be considered in applying controls: effectiveness of technology transfer.

The transfer of technology out of the laboratory and into use is not an easy task. It is a critical part of the work of an industrial laboratory, and I can assure you that it does not go very well if you rely on reports and documents alone. There is no reason to believe that such processes are very effective in any situation where the objective is to put technology to work in a practical way. Transferring equipment and detailed know-how is much more effective.

We should be highly concerned with the Soviets' acquisition of know-how and equipment; we should also put strict controls on such things as equipment design drawings. Once again, the fence protecting these controls must surround other friendly nations, not the U.S. alone, because many of those nations are producing equipment as sophisticated as our own.

Let me conclude by summing up the recommendations I have made.

First, the areas of fundamental scientific and engineering research should remain unfettered by additional controls, even in dual use areas. The harm we would do to our leadership by such controls would outweigh any additional protective benefits that would accrue.

Second, we should distinguish clearly between military criticality and military utility.

Third, foreign availability should be defined in terms of functional equivalence. And we should permit general licenses for the export of critical technology to COCOM nations or other nations with which we have bilateral agreements.

Finally, our export control regulations regarding non-Communist countries should focus on controlling the highly effective technology transfer mechanisms, such as the transfer of turnkey factories, process equipment, and extensive transfer of manufacturing techniques or teaching of those techniques.

By such means as these, I believe we can achieve the combination of leadership and protection that enables us to achieve the objective we all share: assuring that the United States is technologically superior to any adversary in weapons and defense, and remains that way.

Excerpted from a speech at the National Academy of Sciences' Meeting on Export Controls and Technology Policy

Student Experiments on

1

NASA
SPACELAB

1. Student Shawn Murphy and his advisor, Michael Martin of Rockwell International Corporation, Space Systems Group, preparing Murphy's experiment on the growth of an indium crystal in space.
2. Astronaut Jack Lousma inspects the insect colony experiment—prepared by Todd Nelson, Adams, Minnesota and sponsored by Honeywell Inc. Avionics Division—during a March 1982 Shuttle flight. The project, intended to study insects in flight motion, was the first of the SSIP winners to fly. The box contained bees, moths and flies.
3. Pictured are the 1984 national winners of the Student Shuttle Involvement Program at the SSIP Awards Conference in June. Back row, left to right: Brian L. Vlcek, Parma, Ohio; John M. Hendricks, Michigan City, Indiana; Lance G. Jeffers, Hot Springs, Arizona; and Harold A. Christy, Chicago, Illinois. Front row, left to right: Emma C. Redmond, Greenwich, Connecticut; Carla M. Saturnelli, Cornwall-on-Hudson, New York; Karen L. Jarrard, Gaithersburg, Maryland; Kenro Kusumi, Raleigh, North Carolina; George A. Gerliczy, Ridgewood, New Jersey; and Jane M. McCabe, Bowie, Maryland.

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3

the Space Shuttle

BY ELLEN KELLY

An experiment aboard the recent Flight 41-D of the Shuttle Orbiter *Discovery* sought to determine if a thallium-doped crystal of indium will, in the absence of gravity, form a more perfect crystal. Its goal: to develop advanced crystals for use in the communications devices ranging from satellites to transistor radios.

Another project, designed to examine the effects of weightlessness on arthritis, flew on a *Challenger* flight earlier this year. Using eight white rats, the experiment hypothesized a relationship with human arthritis, based on relief arthritic patients receive from submersion in water because of water's buoyancy and its offsetting effect on the force of gravity.

The connection between these experiments—and 48 others designed for Shuttle flight—is that each is the brainchild of a high school student. Selected as national winners in the Student Shuttle Involvement Program (SSIP), these students developed their own proposals and may have the opportunity to consult with NASA and corporate sponsors in the flight planning and eventual analysis of the post-flight data. The crystal experiment—designed by Shawn P. Murphy, Newbury, Ohio and sponsored by Rockwell International Corporation—and the arthritis experiment—developed by Daniel J. Weber, New York City and sponsored by General Dynamics Corporation and Pfizer, Inc.—were prepared for Shuttle flight by the students, their teacher-advisors, their corporate sponsors and NASA.

Sponsored jointly by NASA and the National Science Teachers Association (NSTA), the program has attracted more than 10,000 applications since its inception in 1980. Each year, 20 winners are selected from each of 10 regions to participate in a regional symposium at a NASA research center. From this group of 200, up to 10 national winners are chosen by a panel of 20 judges composed of NASA and other scientists, engineers, and educators. To date, nine of the 50 winning experiments have flown and at least six will go within the next year.

The first student experiment to be flown was launched on the third Shuttle test flight in March 1982. Developed by Todd Nelson, then a high school student from Adams, Minnesota and sponsored by Honeywell Inc. Avionics Division, the experiment was entitled "Insects in Flight Motion Study." It involved the flight responses and other activities of flies, bees and moths under weightless conditions.

Each national winner obtains—through NASA—a corporate sponsor to accompany him through construction of the experiment, required design reviews and flight preparedness procedures. If all requirements are met, a flight assignment is made.

One 1981 national winner, D. Scott Thomas, Johnstown, Pennsylvania said, "It was my experiment all the way. I was there to brief the astronauts, there to watch the launch, and there at mission control to monitor the experiment." His proposal, sponsored by Morton Thiokol, Inc. and designed to study the effects of zero gravity on circulation patterns in liquids, flew in November 1982. Because it didn't work as expected, it is being modified and scheduled for reflight. "There are so many benefits to the program," Thomas said. "Getting to work with scientists and professionals to apply the scientific method is a great experience."

The purpose of the program, according to NASA SSIP Director Michael Bowie, is twofold. "We want not only to motivate high school students to pursue scientific research in hopes they will be the future for American high-tech industry, but our objective is also that the student experiments can contribute now to space exploration. The students and their corporate sponsors make great teams for pursuing innovative, valuable projects."

That student-corporate partnership has indeed been proven mutually beneficial so far, Bowie said. He cited one example: Timothy D. Maclay, Springfield, Pennsylvania, a 1982 winner. Because Maclay's experiment involved a component difficult to obtain—an atomic clock—it was relegated to a back burner. In the meantime, Maclay was placed with Bendix Aerospace division of Allied Corporation for a 1983 summer internship. The results were so positive that he was asked back this summer for another internship, and Bendix is now seriously looking into the possibility of pursuing his original proposal.

"The Student Involvement Program gives exceptional students a perfect opportunity to get a headstart on their career development," said Mike Martin of Rockwell, sponsor for Shawn Murphy's crystal experiment. "Also, the program is valuable to the companies these students may eventually work for because the experience gives the student the opportunity to see how things are really

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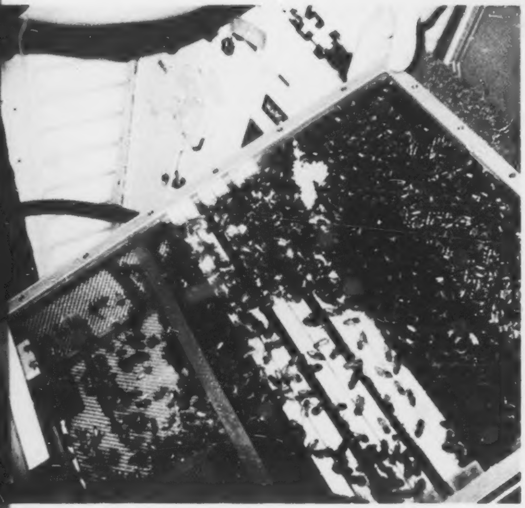

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4. Student scientist Scott Thomas of Johnstown, Pennsylvania, with equipment for his winning experiment, "Convection in Zero Gravity," a study of the circulation patterns occurring in weightless liquids. Sponsored by Morton Thiokol, Inc., the system flew in November 1982, and is scheduled to go again with several modifications.
5. This colony of some 3,000 honeybees flew on the April 1984 mission of the Shuttle Orbiter *Challenger.* Designed by Dan Poskevich, Waverly, Texas, and sponsored by Honeywell Inc., the projects was aimed at comparing the production of honeycombs on Earth and in space.

done in the industry."

Murphy's experiment, Martin said, is the first American-sponsored floating crystal test to be made in space. "We picked Shawn's proposal because it is a valid one, and it provided a test flight for our hardware—the Fluids Experiment Apparatus."

The student experiments are placed in lockers and stored in the mid-deck section of the Shuttle Orbiter, allowing for easy astronaut access during the flight. The dimensions of the locker are approximately 17 by 11 by 20 inches, and students are required to limit the time the astronauts devote to their projects during the flight to one hour.

The proposals are judged in four areas—scientific validity, suitability as a space science activity, creativity and originality, and organization and clarity. Proposals cannot exceed 1,000 words and may have input from teacher-advisors. The NSTA Student Guide outlines specific requirements for writing proposals and contains examples of past winning abstracts. The emphasis here, according to NSTA, is to make the contest not only an exercise in science, but a writing and organizational lesson as well.

In order to involve students not interested in science or space exploration, SSIP developed a public relations contest among high school newspapers last year. The student who best promotes the SSIP, whether through an ad or newspaper article, wins a trip to watch a Shuttle launch at Kennedy Space Center. The 1984 award was shared by two students—Amy Cleveland and Robin Pouilly of Douglas County High School, Colorado. Pouilly wrote two articles explaining SSIP, and Cleveland drew graphics of the Shuttle to accompany them.

The 1984 SSIP national winners were chosen in May and honored at the annual Awards Conference in July, held in Washington, D.C. Each of the 10 winners presented his proposal to NASA officials and the press, toured the National Air and Space Museum, attended a reception at the Museum and received an award at the annual SSIP Banquet at the Washington Hilton Hotel. NASA is now looking for sponsors for eight of the 10 winners. "We're anxious to get sponsors for all the winning experiments," Bowie said. "The success of the entire program depends on locating companies that can start the whole process by supplying the hardware and consultation vital to getting the projects on a Shuttle flight."

The 1985 contest is already underway. Proposals must be submitted to regional directors by February 1, 1985, and winners will be selected in May 1985.

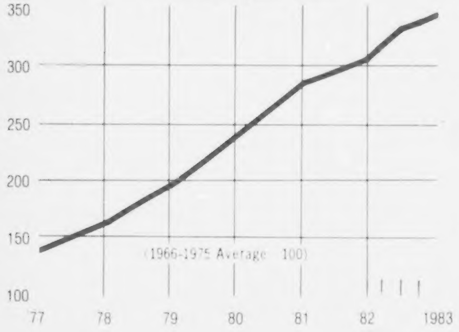
Mike Martin, Rockwell: "The Student Involvement Program gives exceptional students a perfect opportunity to get a headstart on their career development. Also, the program is valuable to the companies these students may eventually work for because the experience gives the student the opportunity to see how things are really done in the industry."

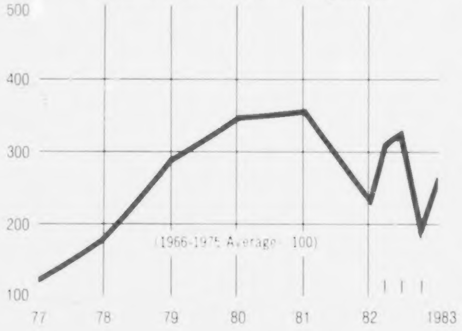
Information, applications and student guides can be obtained from the National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington D.C. 20009.

In launching student experiments, SSIP is a proven successful vehicle for inspiring creativity in high school students, developing talent for the American aerospace industry and fostering advanced experimentation for future space exploration. The countdown is for excellence in scientific thought.

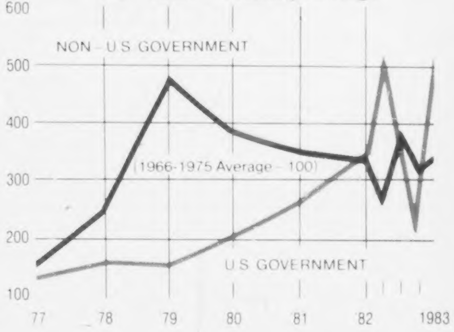
AEROSPACE ECONOMIC INDICATORS

CURRENT


Total Aerospace Sales


Value of Civil Aircraft Shipments[r]

OUTLOOK


New Orders — Monthly Average

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD**	LATEST PERIOD 4th QTR. 1983
AEROSPACE SALES: TOTAL	**Billion $**	**Annually*** **	**24.2**	**75.5[r]**	**80.9**	**83.8**
(as reported by the Bureau of the Census)	**Billion $**	**Quarterly**	**6.1**	**20.4[r]**	**20.6**	**23.3**
AEROSPACE SALES: TOTAL	***Billion $***	***Annually**** **	***25.6***	***36.5[r]***	***37.9[r]***	***38.9***
(in constant dollars, 1972=100)	***Billion $***	***Quarterly***	***6.4***	***9.7[r]***	***9.5***	***10.7***
AEROSPACE PRIME CONTRACT						
AWARDS: TOTAL	**Billion $**	**Quarterly**	**5.8**	**26.5[r]**	**16.5[r]**	**28.6**
U.S. Government	**Billion $**	**Quarterly**	**4.1**	**19.0[r]**	**9.1**	**21.4**
Other Customers	**Billion $**	**Quarterly**	**1.7**	**7.5**	**7.4[r]**	**7.2**
BACKLOG (Major Aerospace Mfgrs): TOTAL	**Billion $**	**Quarterly**	**28.6**	**105.8[r]**	**113.8**	**119.8**
U.S. Government	**Billion $**	**Quarterly**	**15.9**	**60.1[r]**	**69.6**	**76.9**
Other Customers	**Billion $**	**Quarterly**	**12.7**	**45.7[r]**	**44.2**	**42.9**
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	**Million $**	**Quarterly**	**2,712**	**8,850**	**8,726**	**11,733**
Aircraft Procurement	**Million $**	**Quarterly**	**1,986**	**6,604**	**6,315**	**9,397**
Missiles Procurement	**Million $**	**Quarterly**	**726**	**2,246**	**2,411**	**2,336**
Aerospace Outlays: TOTAL	**Million $**	**Quarterly**	**2,405**	**6,642**	**6,549**	**7,636**
Aircraft Procurement	**Million $**	**Quarterly**	**1,741**	**5,502**	**5,121**	**5,815**
Missiles Procurement	**Million $**	**Quarterly**	**664**	**1,140**	**1,428**	**1,821**
NASA RESEARCH AND DEVELOPMENT[a]						
Obligations	**Million $**	**Quarterly**	**780**	**1,515**	**1,429**	**1,912**
Expenditures	**Million $**	**Quarterly**	**789**	**1,289**	**1,395**	**1,626**
EXPORTS						
Total (including military)	**Million $**	**Quarterly**	**1,038**	**4,151**	**3,427**	**3,695**
New Commercial Transports	**Million $**	**Quarterly**	**345**	**688**	**606**	**970**
EMPLOYMENT: TOTAL	**Thousands**	**End of Quarter**	**1,166**	**1,150**	**1,152**	**1,171**
Aircraft	**Thousands**	**End of Quarter**	**650**	**601**	**577**	**585**
Missiles & Space	**Thousands**	**End of Quarter**	**114**	**130**	**146**	**149**
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	**Dollars**	**End of Quarter**	**4.38**	**11.77**	**11.88**	**Not Available**
PROFITS (after tax) BASED ON SALES						
Aerospace	**Percent**	**Annually*** **	**2.7**	**3.3**	**3.3[r]**	**3.5**
	Percent	**Quarterly**	**2.7**	**3.1**	**3.6**	**4.0**
All Manufacturing	**Percent**	**Annually*** **	**4.8**	**3.5**	**3.6**	**4.1**
	Percent	**Quarterly**	**4.8**	**2.8**	**4.3**	**4.5**

Source: Aerospace Industries Association

* 1966-1975 quarterly averages are computed as one-fourth of annual averages

** Preceding period refers to quarter preceding latest period shown

*** Annual data are computed as the sum of the previous four quarters

r Revised

a Effective 4th Quarter 1983, includes new budget category Space Flight, Control, & Data Communications

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D.C. 20036

AIA

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